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THE

JOHN MURRAY EXPEDITION

1933–34

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THE

JOHN MURRAY EXPEDITION

1933–34

SCIENTIFIC REPORTS

VOLUME VI

ZOOLOGY

B. M.
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REPORT ON THE ECHINOIDEA OF THE MURRAY EXPEDITION

PART I

BY

TH. MORTENSEN

WITH TEN TEXT-FIGURES AND SIX PLATES

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REPORT ON THE ECHINOIDEA OF THE MURRAY EXPEDITION

PART I

BY

TH. MORTENSEN

WITH TEN TEXT-FIGURES AND SIX PLATES.

INTRODUCTION.

THE Regular Echinoidea collected by the Murray Expedition number in all 35 species. In comparison with the number of species collected by the "Investigator", 50 species (less one—*Aspidodiadema annulatum*, which is a *Diadema*, probably *D. Savignyi*), the Murray collection lags somewhat behind. In regard to the Cidarids, however, it compares very favourably with the "Investigator" collection, containing no less than 12 species, as against 11 species in the "Investigator" collection; but whereas the "Investigator" collection contained only 2 new species, the present collection contains no less than 5 new species, one of them representing a new generic type, *Lissocidaris*. Two of the new species, *Cidaris mabahissæ* and *Lissocidaris fusca* are of very great zoogeographical interest, as they belong to the sub-family *Cidarina*, hitherto known only from the Atlantic. Another very interesting discovery is *Goniocidaris indica*, this genus, so richly developed in the Japanese-Malayan-Australian region, being not otherwise represented in the Indian Ocean. On the whole the Indian Ocean is very rich in Cidarids, comparing favourably with the Malay region, the richest in the world in this regard, and far surpassing the Atlantic and the West American region.

Among the Echinothurids *Arœosoma alternatum*, of which only a single specimen was known till now, is of considerable interest, and among the Diadematids *Centrostephanus nitidus* stands out as the most important.

The discussion of the zoogeographical problems will be included in Part II of this report; attention should here only be called to the rich fauna of deep-sea Echinoids in the Pemba Strait. It is regrettable that most of the specimens collected there, particularly the Echinothurids, are in a very poor state of preservation.

List of the Species Collected.

1.	*Histocidaris denticulata* Koehler	Maldives.
2.	*Goniocidaris indica* n. sp.	Pemba Strait; Maldives.
3.	*Stereocidaris indica* Döderlein	Maldives.
4.	*St. squamosa* Mrtsn.	Pemba Strait.
5.	*St. reducta* n. sp.	Maldives.
6.	*Cidaris mabahissæ* n. sp.	Maldives.
7.	*Lissocidaris fusca* n. g., n. sp.	Maldives.
8.	*Stylocidaris bracteata*, var. *mauritiana* Mrtsn.	Cape Gardafui.
9.	*S. lævispina* n. sp.	Cape Gardafui.
10.	*Acanthocidaris curvatispinis* (Bell)	Cape Gardafui.
11.	*Prionocidaris baculosa* (Lamk.)	S. of Arabia; Gulf of Persia.
12.	*P. pistillaris* (Lamk.)	Cape Gardafui.
13.	*Phormosoma bursarium* A. Agassiz	Pemba Strait; Maldives; Gulf of Aden.
14.	*P. verticillatum* Mrtsn.	Maldives; Gulf of Aden.
15.	*Tromikosoma (?) uranus* (Wyv. Thoms.)	1° 26′ S., 66° 34′ E.
16.	*Hygrosoma hoplacantha* (Wyv. Thoms.)	Gulf of Aden; Pemba Strait; Maldives.
17.	*Sperosoma* sp.	Mombasa.
18.	*Arœosoma alternatum* Mrtsn.	Pemba Strait.
19.	*Asthenosoma varium* Grube	Red Sea.
20.	*Salenocidaris miliaris*, var. *indica* n. var.	Maldives; Andamans.
21.	*Cœlopleurus Maillardi* (Michelin)	Cape Gardafui.
22.	*Diadema Savignyi* Michelin	Cape Gardafui.
23.	*Chætodiadema africanum* H. L. Clark	Pemba Strait.
24.	*Echinothrix calamaris* (Pallas).	Cape Gardafui.
25.	*Centrostephanus nitidus* Koehler	Maldives.
26.	*Micropyga violacea* de Meijere	Pemba Strait.
27.	*M. tuberculata* A. Agassiz	Pemba Strait.
28.	*Plesiodiadema amphigymnum* (de Meijere)	Off Minikoi.
29.	*P. molle* (Döderlein)	1° 26′ S., 66° 35′ E.
30.	*Salmacis erythracis* H. L. Clark	Cape Gardafui.
31.	*Temnopleurus Reevesii* (Gray)	Cape Gardafui.
32.	*T. apodus* (A. Ag. & H. L. Clark.	Pemba Strait.
33.	*Temnotrema siamense* (Mrtsn.)	S. Arabia; Cape Gardafui; Pemba Strait.
34.	*T. scillæ* (Mazzetti)	S. Arabia.
35.	*Prionechinus Agassizi* Wood-Mason & Alcock.	Pemba Strait.

Family Cidaridæ.

Histocidaris denticulata Koehler.

Histocidaris denticulata, Koehler 1927, "Investigator" Ech. III, p. 10, pl. i, figs. 1–3, 6, 7, pl. ii, fig. 1, pl. xxiii, fig. 1; Mortensen, 1928, Monograph of the Ech. I, p. 100, pl. lxxv, figs. 14, 15, pl. lxxvii, fig. 19.

Occurrence.

St. 145, 2.iv.1934, 4° 59′ S., 73° 16′ E., 494 m., off the Maldives.* 3 specimens.

Descriptive Notes :

H.d. mm.	V.d. mm.	Apical system.	Peristome.	Number of I.A.	Number of A. pro I.A.	Longest spines.
80	71	29 mm. (36·2% h.d.)	23 mm. (28·7% h.d.)	12–13	11–12	152 mm.
79	71	30 ,, (38 % ,,)	25 ,, (31·6 % ,,)	12	11–12	134 ,,
66	58	26 ,, (39 % ,,)	20 ,, (30 % ,,)	11–12	11–12	124 ,,

These specimens on the whole agree very completely with the description given by Koehler and the present author (*op. cit.*). It should only be pointed out that the oculars are only partly insert, viz., in Specimen 2 only Oc. I, in Specimen 1 Oc. I and V, and in Specimen 3 Oc. I, V and IV, the latter only just touching the periproct. In Specimen 1 the marginal ambulacral tubercles are rather irregular, in Specimen 2 very regular, in Specimen 3 somewhat intermediate.

The colour of all three specimens is a creamy white.

Goniocidaris indica n. sp. (Pl. I, figs. 1–4; Pl. V, figs. 4, 7; Pl. VI, figs. 17, 18.)

Occurrence.

St. 115, 15.i.1934, 5° 05′ S., 39° 22′ E., 640 m., between Pemba Island and the African continent. 7 specimens.

Descriptive Notes :

H.d. mm.	V.d. mm.	Apical system.	Peristome.	Number of I.A.	Number of A. pro I.A.	Longest spines.
25	17	12 mm. (48 % h.d.)	9 mm. (36 % h.d.)	7–8	9–10	44 mm.
22	16	11·5 ,, (52·5% ,,)	9 ,, (40·9% ,,)	7–8	9–10	38 ,,
20	13·5	10 ,, (50 % ,,)	8 ,, (40·9% ,,)	7–8	10–11	40 ,,
16	11	8 ,, (50 % ,,)	6·5 ,, (40·6% ,,)	7	7–8	35 ,,

Shape of test low, rounded, usually somewhat flattened above and below; in one specimen, however, the apical system rises gently, in continuation of the rounding of the test, the shape being thus almost spherical; but even in this latter specimen the oral side is somewhat flattened.

Ambulacra fairly broad, *c.* 40% the width of the interambulacra; in the largest specimen they are, however, only *c.* 33%. They are rather distinctly sinuate. Interporiferous zone somewhat more than twice the width of a pore-zone. Marginal series of tubercles quite regular, the tubercles not contiguous, there being even a couple of small miliary tubercles between them. Inside the marginal tubercles the plates wholly covered by a number (*c.* 4–6) of small irregularly arranged tubercles. The admedian end of the horizontal sutures sunken, forming distinct pits, which may be connected by a distinctly

* The labels of two of the specimens give the station number 146, but the depth 510 m. According to the published Station List St. 146 has a depth of only 37 m. There can thus be no doubt that 146 is erroneous, and that all three specimens came from the same station, 145. The error in the station number is probably due to the fact that two hauls were made at the same station, 145, at the same depth. That the depth given on the labels as 510 m. in the published Station List as 494 m. is another slight discrepancy, fortunately of no importance, and is due to the fact that the greater depth, noted on the label and given by the Echo-sounder, was provisional, and was subsequently corrected for salinity and temperature.

sunken median line. The pores small, round ; the wall elevated, the ridge rather low. (Pl. V, fig. 4.)

Interambulacra.—Areoles rather small, conspicuously sunken ; only the two lowermost confluent. The scrobicular tubercles fairly conspicuous, the plates outside the scrobicular circle closely covered by small tubercles, leaving no naked median line. The admedian end of the horizontal sutures deepened so as to form distinct pits.

Apical system.—All oculars exsert. Genital pores in the males situated about in the middle of the genital plates, in the females near the distal edge, or even rupturing the edge. One specimen is abnormal in having 2–3 pores in three of the genital plates (Pl. I, fig. 1 ; Text-fig. 1). The whole apical system rather closely covered by small tubercles, leaving only a more or less conspicuous bare edge (Text-fig. 2). *Peristome* distinctly smaller than

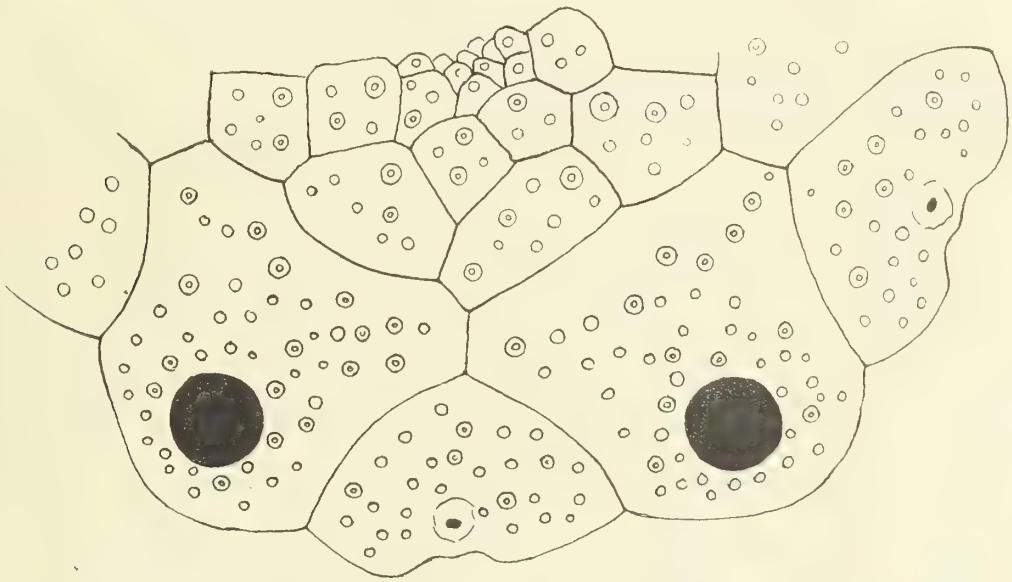
Text-fig. 1.—Part of the apical system of *Goniocidaris indica*, with multiple genital pores. Male specimen. × 12.

the apical system ; it is perfectly flat. There are 5–6 ambulacral plates in a series, 3–4 interradial plates ; in the largest specimen these latter plates are somewhat irregular, the 2nd and 3rd plate being divided into two.

Primary spines c. 1½–2 times the h.d. They are slender, tapering to a point, rarely a very small terminal crown on some of the ambital spines. They appear nearly smooth, the low thorns being (in not too much worn spines) almost hidden in the dense coat of anastomosing hairs. The basal disc is well developed on the adapical side of the larger ambital spines. The uppermost primaries are widened into a broad, flat disc ; it is excentrical, the adapical side being the broader. The edge of the disc appears to be entire on the fully formed discs, whereas in the not fully formed it is deeply serrate. One of the smaller specimens has 6 apical discs, which means that when full-grown this specimen would have had 10 discs ; whether this will be the rule in this species cannot be stated definitely, the material available being not sufficiently well preserved, several of the adapical spines

having been lost; but it rather seems that as a rule there are only 5 adapical discs also in the adult. The discs have a not very dense coat of simple hairs on the upper side. The adoral primaries are slender, a little curved, smooth, with an indication of lateral serrations; the third is more distinctly serrate and, together with the fourth, forms the transition to the ambital spines. *Secondary spines*: The scrobicular spines are *c.* 2 mm. long, rather thick, smooth, almost rectangular. The marginal ambulacral spines much like the scrobicular ones, only more slender and a little shorter. The miliary spines are erect, not pointed.

Pedicellariæ.—No large globiferous pedicellariæ found on any of the specimens. The small globiferous well developed; the valves are rather elongate, with a small end-tooth (Pl. VI, figs. 17, 18). Tridentate pedicellariæ of the large coarse form (Pl. V, fig. 7), fairly common in some of the specimens. *Spicules* of the tube-feet nearly smooth rods.



Text-fig. 2.—Part of apical system of *Goniocidaris indica*. Female specimen. × 12.

Colour.—Primary spines white, secondaries straw-coloured. Also the denuded test is of a light straw-colour, not pure white.

Biology.—As usual, the primary spines are covered by various foreign organisms—worm-tubes, hydroids (in tufts at the point of the spines), a white Scalpellid (mainly on the apical discs). Also an Ophiurid (*Ophiacantha* sp.) was found between the spines on one of the specimens.

Remarks.—It is clear that this species belongs to the *Aspidocidaris* group within the great genus *Goniocidaris*, and that it is particularly related to *Goniocidaris Sibogæ* Mrtsn. from the Malay Archipelago. It differs from it, as also from the related Japanese species *Goniocidaris alba* Mrtsn., mainly by its more slender and much more smooth primary spines. Also its darker colour makes a conspicuous difference, the two said species being a pure white. Possibly, if we had specimens from intermediate localities, we should have to regard all these three species as local variations of one and the same species; but as long as we know one only from Japan, the other from the Malay Archipelago, and the third from the western part of the Indian Ocean, we are not justified in neglecting the small differences that exist and combining them all together into one species.

In my Monograph I, p. 154, Note 2, mention is made of the existence in S. African Seas (off Cape St. Blaize, Mossel Bay) of a *Goniocidaris* apparently allied to *G. fimbriata* (de Meijere). There can hardly be any doubt but that it will prove to be identical with the present species, which will no doubt be found to occur all along the East African coast.

The genus *Goniocidaris* being otherwise confined to the Japanese, Malayan and Australian–New Zealand seas, represented there by a considerable number of species, it is of very great zoogeographical interest that a species of the genus has now been found to exist in the western part of the Indian Ocean, not a single species having hitherto been found in the whole of the Indian Ocean. It would be of very great interest to know whether the species is confined to the western part or whether it is distributed all over the Indian Ocean. In any case the centre of the genus *Goniocidaris* is in the Malay Archipelago, from whence this Indian Ocean species represents an isolated radiation.

Stereocidaris indica Döderlein.

Stereocidaris indica Döderlein, 1906, Ech. Deutsche Tiefsee-Exped., p. 104, taf. x, figs. 1,2, taf. xi, figs. 1–6 and taf. xii, figs. 3–10, etc. ; Mortensen, 1928, Monogr. Ech. I, p. 263, pl. xxv, fig. 1, and pl. lxxi, figs. 4, 5, etc.

Occurrence :

St. 143, 30.iii.1934, 5° 16′ S., 73° 23′ E., 797 m., off Maldive Archipelago, 1 specimen.

The specimen is abnormal and in a poor state of preservation, nearly all the larger primary spines being lost. It is impossible to decide to which of the diverse varieties established by Döderlein this specimen should be referred. I rather think it is the var. *africana*, but do not venture to say so definitely. None of the spines preserved have any wing-like crests.

Stereocidaris squamosa Mrtsn. (Pl. IV, figs. 2, 3.)

Stereocidaris squamosa Mortensen, 1928, Monogr. Ech. I, p. 245, pl. xx, figs. 4–6, pl. lxx, fig. 7 and pl. lxxx, figs. 10–16 ; 1932, New Contrib. Knowl. Cidarids, p. 151.

Occurrence :

St. 109, 13.i.1934, 5° 11′ S., 39° 34′ E., 640 m., strait between Pemba Island and the African continent. 1 specimen.

This is an adult specimen, 44 mm. h.d., in fair condition. The specimen figured in my monograph having lost most of its primary spines, I have thought it desirable to give photographic figures of the present specimen, which convey a better impression of what the species looks like.

The specimen differs from the type in the interporiferous zone being wholly covered by secondary tubercles, each plate carrying 2–3 smaller tubercles adradially to the marginal one, instead of one relatively large one, as shown in pl. lxx, fig. 7, of the Monograph. Also in the colour of the test it differs slightly from the type in there being scarcely any trace of a greenish tint.

To the statement in the description of this species (Monograph, p. 246) that the primary spines on the whole give the impression of being very smooth it should be added that this holds good mainly of the better preserved spines, in which the hair coat is left intact. Where the hair coat has been lost, as is the case of most of the spines of the present

specimen, the spines show rather distinct longitudinal lines of small, low serrations. One of the upper spines has a fairly conspicuous terminal crown. The longest spines are *c.* 75 mm., thus about $1\frac{2}{3}$ the h.d.

On the present specimen the peristome is deeply sunken, particularly in the interambulacra, so that it gives almost the impression of there being five interradial pouches. This tends to suggest that this species may be brood-protecting, carrying its young ones on the peristome ; I think, however, that the sunken condition of the peristome is due to the specimen having been left lying dry on deck for some time before being preserved in alcohol. There are, at any rate no young ones on the present specimen (or on any of the other specimens I have examined ; judging from the size of the genital pores the present specimen is a female).

Stereocidaris reducta n. sp. (Pl. II, figs. 1–4 ; Pl. V, fig. 1 ; Pl. VI, figs. 14–16.)

Occurrence :

St. 157, 6.iv.1934, 4° 44′ N., 72° 55′ E., 229 m., off Maldive Islands. 4 specimens.

Descriptive Notes :

H.d. mm.	V.d. mm.	Apical system.	Peristome.	Number of I.A.	Number of A. pro I.A.	Longest spines.
64	43	26 mm. (40·6% h.d.)	27 mm. (42 % h.d.)	(6) 7	21–24	60 mm.
61	44	26 ,, (42·6% ,,)	25 ,, (45·9% ,,)	6–7	22–26	68 ,,
58	41	24 ,, (41·4% ,,)	24 ,, (41·4% ,,)	6–7	21–25	52 ,,
56	45	21 ,, (37·4% ,,)	23 ,, (41·1% ,,)	6–7	21–23	54 ,,

Shape of the test almost spherical, only the oral side more or less depressed, though not flattened.

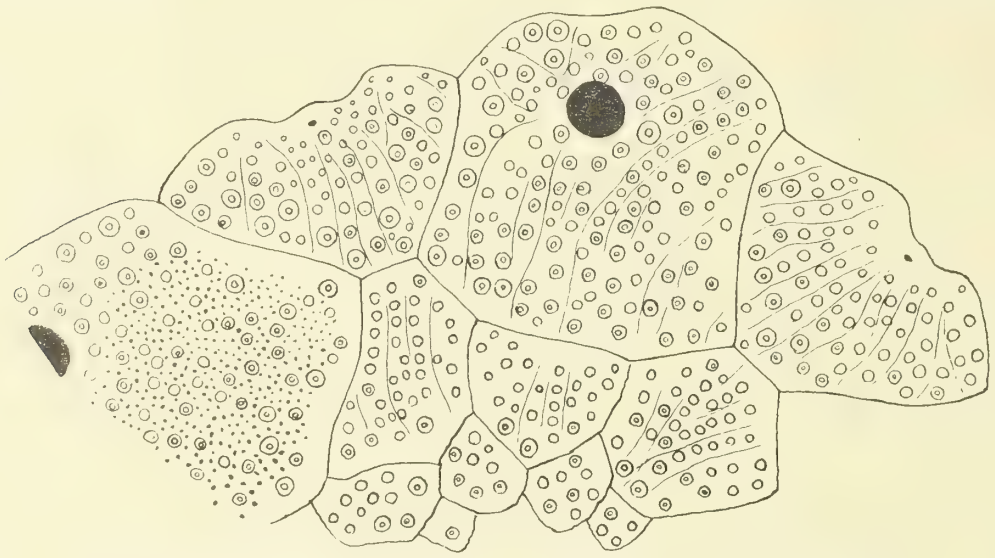
Ambulacra rather broad, about one-third the width of the interambulacra or even more than one-third. They are only slightly sinuate, and less so adapically than on the oral half. Interporiferous zone rather unusually broad, about twice the width of a pore-zone. Marginal series of tubercles very regular ; the tubercles are small, but contiguous. Adradially to the marginal tubercle each plate carries 3–4 not much smaller tubercles, forming more or less regular horizontal series. The whole interporiferous zone closely covered by these secondary tubercles, there being no naked median line, whereas the sutures between the plates are fairly distinct. The pore-zones scarcely sunken ; the pores are of medium size, rather distant, the wall being broad, but nearly flat ; the ridge is very inconspicuous (Pl. V, fig. 1).

Interambulacra.—The areoles are rather large and deep, well separated even to the peristome. The two uppermost plates in one or both series with much reduced primary tubercles, or the tubercle totally lacking on the uppermost plate. As these upper plates are very high, this results in the whole upper side being devoid of primary spines. The primary tubercles do not show any trace of crenulation. The scrobicular edge not thickened ; the scrobicular tubercles are fairly large, but as they are placed on the very edge of the areole, reaching half way down the sides, they are rather inconspicuous. Outside the scrobicular circle the plates are covered, on all sides the areole, by a fine, very close and uniform tuberculation, leaving no naked, or sunken, median line. A number of sharp, sunken lines passing from areole to areole, across the median area or between the areoles of the same series, produce a more or less conspicuous arrangement of the

secondary tubercles, in horizontal or vertical lines, or in arches. A varying number of impressions from the large globiferous pedicellariæ are found along the sutures, and also partly on the plates themselves. The median area is broad, at the ambitus equalling the width of the areoles.

Apical system.—The ocular plates all rather broadly insert. Madreporite not enlarged. The whole apical system closely covered by a uniform, fine tuberculation, partly rather distinctly arranged in radiating lines separated by sharp furrows like those of the interambulacra (Text-fig. 3). *Peristome* about the same size as the apical system. There are *c.* 15 ambulacral plates in a series, the pores forming a regular straight line. The interradii are rather unusually broad, the plates being partly arranged in double series ; there are 10–12 interradial plates, reaching almost to the edge of the mouth.

Primary spines slender, cylindrical, or tapering to a point. There may be a fairly distinct terminal crown on some of the ambital spines ; it is oblique, the adapical side of



Text-fig. 3.—Part of apical system of *Stereocidaris reducta*. × 5.

it being the larger. Some of the older spines in one of the specimens look obliquely worn at the tip, as if they had served for walking on them. The shaft of the primary spines is provided with about 15 low, smooth, or very finely serrate ridges, the space between these ridges being filled up by a coat of anastomosing hairs. The surface of the spines, when well preserved, is accordingly rather smooth. There is a short shining neck, not much longer than the collar, which is *c.* 1·5 mm. long, increasing very markedly in thickness towards the inconspicuous milled ring. The oral primaries are all somewhat trumpet-shaped widened at the point, and distinctly longitudinally ridged. The primary spines are, on the whole, remarkably brittle, only few being preserved unbroken.

Secondary spines.—The scrobicular spines are *c.* 4 mm. long, closely appressed. They are almost rectangular, excavated along the midline on their outer side. The marginal ambulacral spines *c.* 3 mm. long, flat, closely appressed. The secondary spines very small, squamiform, closely appressed, with a more or less conspicuous glandular ampulla. The passage from the scrobicular and marginal ambulacral spines to the small secondary spines is very abrupt.

Pedicellariæ.—The large globiferous pedicellariæ rather numerous, placed mainly

along the horizontal sutures in the interambulacra, but also on the plates themselves ; also in the ambulacra they may occur, as well as on the apical system. The valves of the typical *Stereocidaris* shape ; the stalk quite short (Pl. VI, fig. 15). Small globiferous pedicellariæ without end-tooth, as typical (Pl. VI, fig. 14). Tridentate pedicellariæ well developed, head *c.* 1 mm. long ; the valves rather slender, joining in nearly their whole length (Pl. VI, fig. 16). *Spicules* of tube-feet slender, rather smooth rods. The gonads and intestinal wall apparently totally devoid of spicules.

Colour.—The general colour is a light brownish. The primary spines, when fresh, light pinkish. The scrobicular spines a dark olive, with the edges lighter ; the marginal ambulacral spines also dark olive, at least in their basal part. The denuded test is a rather conspicuous green, particularly on the apical system and the upper part of the interambulacra. At the ambitus it may pass into a reddish tint.

Biology.—Some specimens of a *Crepidula* were found attached to some of the primary spines ; also hydroids and worm-tubes.

Remarks.—This species is related to *St. microtuberculata* (Yoshiwara) and *excavata* Mrtsn., as also to *St. tubifera* Mrtsn., but differs conspicuously from them all in the greater reduction of the primary tubercles on the aboral side. In this regard it is, together with *St. japonica* Döderlein, the most specialized of all recent *Stereocidaris* species.

Cidaris mabahissæ n. sp. (Pl. I, figs. 5, 6 ; Pl. IV, fig. 4 ; Pl. V, fig. 5 ; Pl. VI, figs. 3, 5, 8, 12, 13.)

Occurrence :

St. 140, 26.iii.1934, 2° 40′ S., 73° 22′ E., 515–525 m., off the Maldive Islands. 1 specimen.

Descriptive Notes :

H.d. mm.	V.d. mm.	Apical system.	Peristome.	Number of I.A.	Number of A. pro I.A.	Longest spines.
37	25	17 mm. (46% h.d.)	13 mm. (35% h.d.)	7 (8)	13–14	56 mm.+?

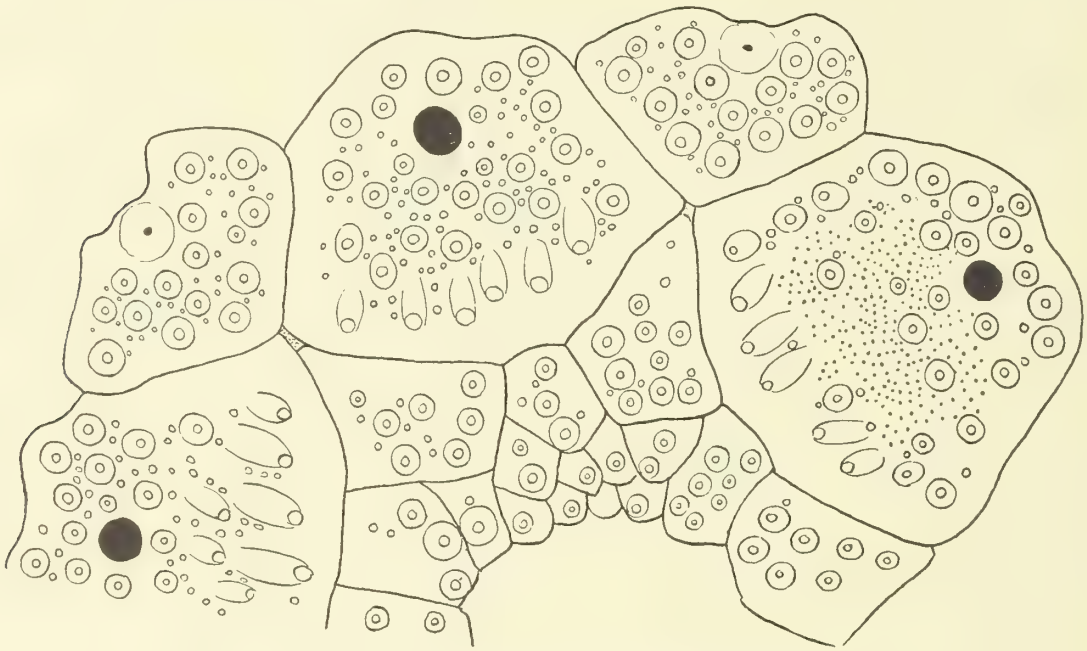
Test conspicuously flattened on the aboral side, less so on the oral side. Sides subvertical, slightly narrowing towards the oral side, the largest width of the test being at the upper ambital part. Circumference round.

Ambulacra scarcely one-third the width of the interambulacra, rather conspicuously sinuate. Interporiferous zone somewhat broader than the pore-zone. Marginal tubercles very nearly contiguous, forming quite regular series. Adradially to the marginal tubercle each plate carries one or two secondary tubercles, which form a fairly conspicuous series adradially to the marginal series. Also some scattered miliary tubercles are found, there being no naked median line. The pores are unusually broad, separated by a very narrow, elevated wall (Pl. V, fig. 5). The ridge is narrow, not very sharp.

Interambulacra.—The areoles of moderate size, fairly deep, well separated, at most the two adoral ones confluent. No trace of crenulation observable. The scrobicular circle not elevated, the tubercles not very conspicuous. Outside the scrobicular circle the plates densely covered with secondary tubercles, which decrease gradually in size towards the slightly sunken median line. The median space is narrow, scarcely half the width of the areoles. The sutures are sharp and well marked, but there is no naked median line. The space to the adradial side of the areoles is narrow, giving room only for very few

secondary tubercles. There are some, not very conspicuous, horizontal lines across the median space, not distinct enough for producing an arrangement in horizontal lines of the secondary tubercles.

Apical system.—The oculars very nearly insert, except ocular IV. Madreporite not enlarged, the pores being confined to a rather small patch in the middle of the plate. The whole apical system somewhat sparsely covered with secondary tubercles, those along the inner edge of the genital plates elongate, comma-shaped; but between the secondary tubercles there are numerous miliary, pedicellariæ-bearing tubercles, the plates being thus wholly covered, with exception of a rather narrow inner border (Text-fig. 4). *Peristome* distinctly smaller than the apical system, very nearly flat. There are 10–11 ambulacral plates in a series, the pores arranged in regular, single series. Inter-



TEXT-FIG. 4.—Part of apical system of *Cidaris mabahissæ*. × 5.

radial plates 3–4 in each series, not reaching the mouth-edge. Edge of the peristome not sunken.

Primary spines.—None of the larger primary spines preserved in full length; they must be about twice the horizontal diameter. They are very slender, cylindrical, scarcely at all tapering. In one of the upper primaries, preserved full length, there is the merest indication of a terminal crown. The shaft is provided with 10–12 finely serrate, not very prominent, longitudinal ridges, the space between which is filled up by a coat of anastomosing hairs. There is a fairly conspicuous, shining neck, *c.* 2 mm. long. The collar is about 1 mm. long, gradually increasing in thickness towards the inconspicuous milled ring. The oral primaries slender, smooth, or with fairly distinct lateral serrations; the 3rd and 4th transitional to the ambital spines. *Secondary spines* not strongly appressed. The scrobicular spines are *c.* 4 mm. long, smooth, somewhat excavated on the outer side, terminating in a rounded point. The marginal ambulacral spines *c.* 3 mm. long, more slender, almost setaceous. Miliary spines likewise setaceous, without glandular ampulla.

Pedicellariæ.—The large globiferous pedicellariæ, which occur in fair numbers, have unusually slender valves, which join only with their terminal part (Pl. VI, figs. 3, 5) ; but the large opening and conspicuous end-tooth are distinctly of the type characteristic of the *Cidarina*. The stalk is rather long and slender, without trace of a limb. The small globiferous form not peculiar, the end-tooth distinct in the smaller samples (Pl. VI, fig. 13), less distinct in the larger, more elongate ones, which form a transition to the tridentate type (Pl. VI, fig. 12). This latter reaches a size of *c.* 2 mm. length of head ; the valves are narrow, slender, not peculiar ; they join in nearly their whole length (Pl. VI, fig. 8). *Spicules* of the tube-feet slender, mostly nearly smooth rods.

Colour.—Primary spines whitish, only the neck with a slight tint of pink. Usually a narrow dark ring on the border between the neck and the collar, which latter is somewhat darker than the neck, more brownish. The secondary spines a light brownish, with a darker median line on the scrobicular spines. The denuded test has a tinge of green on the apical system and the upper primary tubercles ; otherwise it is whitish, the ambulacra being slightly darker, with a tinge of olive in the interporiferous zone.

Biology.—A couple of the primary spines carry some quite large colonies of Hydroids ; otherwise they are rather clean, but a few small *Crepidula* and Scalpellids are found attached to them.

Remarks.—In its general appearance this species is very like the Atlantic *Cidaris cidaris*. But it differs markedly from that species, as also from the other known species of the genus *Cidaris* in the much larger size of the pores. It might be questionable whether this character would not justify regarding *mabahissæ* as the type of a separate genus. I think it preferable, however, to leave it in the genus *Cidaris*, thereby emphasizing the important zoogeographical fact that we have here a representative (or at least a very close relative) in the Indian Ocean of the genus *Cidaris*, which is otherwise confined to the Atlantic Ocean (including the West Indian region).

The present species, together with the next described *Lissocidaris fusca*, are the first representatives of the group *Cidarina* found outside the Atlantic, all previous records of the occurrence of "*Dorocidaris papillata*", or of the genus "*Dorocidaris*", in the Red Sea, the Indian Ocean, the Malay Seas, etc., being erroneous, as I have shown in my Monograph of the Echinoidea, I (pp. 299, 371, etc.).

Lissocidaris n. g.

Pores not conjugate, the wall almost flat. Pores on peristome in single regular series. Primary tubercles perforate, the ambital ones with a trace of crenulation. Madreporite not enlarged. Primary spines long and slender, finely longitudinally striated, but perfectly smooth, the hairs coalescing at the surface so as to form a perfectly dense, smooth layer. Secondary spines not strongly appressed. The large globiferous pedicellariæ with a distinct end-tooth ; stalk very short. Small globiferous pedicellariæ with a small but distinct end-tooth.

Genotype : *Lissocidaris fusca* n. sp.

The character of the large globiferous pedicellariæ shows this genus to belong to the group of the *Cidarina*. Among the genera of this group it recalls by its smooth primary spines *Calocidaris* ; but this smoothness of the spines in the two genera is of totally different morphological value : in *Calocidaris* it is due to the total absence of hairs, the cortex layer

itself being smooth and shining on its surface ; in the present genus the cortex layer is covered by a thick layer of anastomosing hairs, which coalesce so as to form a perfectly smooth surface. There is thus no question but that the present form represents a distinct genus, the more interesting as the group of the *Cidarina* was not hitherto known to be represented outside the Atlantic. Another representative of the same group, likewise from the Indian Ocean, is the species described above under the name of *Cidaris mabahissæ* n. sp.

Lissocidaris fusca n. sp. (Pl. III, figs. 1–3 ; Pl. V, fig. 2 ; Pl. VI, figs. 1, 2, 6, 19.)

Occurrence :

St. 157, 6.iv.1934, 4° 44′ N., 72° 55′ E., 229 m., off the Maldive Islands. 1 specimen.

Descriptive Notes :

H.d. mm.	V.d. mm.	Apical system.	Peristome.	Number of I.A.	Number of A. pro I.A.	Longest spines.
50	34	20 mm. (40% h.d.)	20 mm. (40% h.d.)	8	14–16	64 mm.

Test almost regularly spherical, only flattened above, and somewhat less so on the oral side.

Ambulacra scarcely one-third the width of the interambulacra, slightly sinuate ; interporiferous zone about twice the width of a pore-zone. Marginal series of tubercles perfectly regular ; the tubercles fairly large, contiguous. Adradially to the marginal tubercle each plate carries two or three secondary tubercles, the outer one the larger, and forming a fairly regular series inside the marginal series. There is no naked or sunken median line. The pore-zones only slightly sunken. The pores are separated by a fairly broad, low wall ; the ridge is narrow, not high (Pl. V, fig. 2). A very unusual feature is the existence in a few places of a distinct tubercle (spine) on the middle of the ridge.

Interambulacra.—The areoles are rather small, distinctly separate, even the two lowermost ones scarcely confluent ; those below the ambitus distinctly transverse oval. They are not very deep, the scrobicular edge not elevated or thickened. The 2–3 ambital primary tubercles show traces of crenulation on the adapical side. The scrobicular tubercles of moderate size. Outside the scrobicular circle the plates rather densely covered with secondary tubercles, which decrease gradually in size towards the slightly sunken, but not naked, median line. Also on the outer side of the areoles there is a rather broad space covered with secondary tubercles continuing even to the peristomial edge, a very unusual case in Cidarids. The median area is a little more than half the width of the areoles. On the uppermost interambulacral plates there are some rather deep horizontal lines, continuing across the areoles. This produces the aspect of the secondary tubercles being arranged in horizontal series. On the other plates there is no such linear arrangement.

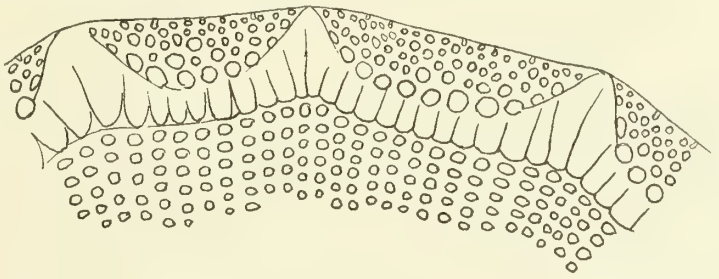
Apical System.—The ocular plates all narrowly insert. The whole apical system covered uniformly by small tubercles (Text-fig. 5). The *peristome* of the same size as the apical system (40% h.d.). There are 10–11 ambulacral plates in a series, the pores in a single, regular line ; 5–6 interradial plates in a fairly regular series, reaching almost to the mouth-edge. Peristomial edge slightly sunken.

The *primary spines* are slender, almost cylindrical, or slightly flattened, at most tapering very slightly ; the tip is not widened. The surface is very smooth, though not

shining. On a closer inspection one sees a number (*c.* 20–35) of fine, smooth, longitudinal lines, not raised above the general surface; in the distal part of the spine these lines become more pronounced ridges, but they remain smooth. On sections of the spines it is seen that these lines are in reality rather high ridges, but the space between them is

Text-fig. 5.—Part of apical system of *Lissocidaris fusca*. × 5.

entirely filled up by a dense mass of anastomosing " hairs ", which form a perfectly smooth outer surface, perforated only by microscopical holes (Text-fig. 6). There is a rather long, shining neck, *c.* 3 mm. long, twice the length of the collar, which latter increases markedly in thickness towards the very inconspicuous milled ring. The oral primaries



Text-fig. 6.—Part of transverse section of a primary spine of *Lissocidaris fusca*. × 85.

are rather broad, flattened, almost the shape of a cricket-bat, but slightly curved towards the end; their sides are smooth, but their surface distinctly longitudinally striped, particularly on the outer (adapical) side. The 3rd and 4th are transitional to the ambital spines.

The *secondary spines* are not strongly appressed. The scrobicular spines are *c.* 5–6 mm. long, slender, not much flattened, terminating in a rounded point. The marginal

ambulacral spines only slightly shorter, but more slender, almost setaceous. The miliary spines likewise setaceous, erect, without any glandular ampulla.

Pedicellariæ.—The large globiferous form is very short-stalked; the valves have a very distinct end-tooth (Pl. VI, fig. 2). Two-valved samples are not rare (Pl. VI, fig. 19). The small globiferous pedicellariæ have slender valves, with a small but distinct end-tooth (Pl. VI, fig. 6). This form is remarkably scarce, a rather unique case among Cidarids, this form being generally very common, in contradistinction to the large globiferous form which is in many species of exceedingly rare occurrence or even apparently totally lacking. The tridentate pedicellariæ have rather coarse valves, which join only in the distal half; there are some more or less developed irregular crests in the blade (Pl. VI, fig. 1). The *spicules* of the tube-feet are nearly smooth rods.

Colour.—The primary spines are a creamy-white, sometimes with a narrow dark ring; the neck is a light pink, the collar darker, more brownish-red. The secondary spines, as well as the skin of the test, a uniform dark red-brown. The denuded test of the same red-brown colour on the apical system and the uppermost interambulacral plates; the ambulacra of somewhat lighter colour, about straw-colour.

Biology.—Among the primaries is found a Polynoid worm; on the larger primaries a number of *Crepidula* are attached, as also some tubes of Serpulids.

Remarks.—The character of the primary spines recalls the genera *Centrocidaris*, *Schizocidaris* and *Kionocidaris*, particularly the first-named. The structure of the large globiferous pedicellariæ show, however, that there is no near relationship between these genera. This peculiar spine-structure must evidently have developed separately along four different lines, and the very similar end-result represents a marked case of convergency.

The two-valved large globiferous pedicellariæ, not known elsewhere in Cidarids, may perhaps be a normal feature in this species; if so that may be another generic character. From the single specimen at hand this, of course, cannot be decided.

Stylocidaris bracteata var. *mauritiana* Mrtsn.

Stylocidaris bracteata var. *mauritiana* Mortensen, 1932, New Contrib. Knowl. Cidarids, p. 161, pls. vii, viii, ix, figs. 10–12, and pl. xii, figs. 3–5, 7.

Occurrence:

St. 24, 9.x.1933, 11° 54′ N., 51° 13′ E., 73–200 m., off Cape Gardafui. 4 specimens.

Descriptive Notes.—These specimens agree very closely with the form from Mauritius described under the above name in my paper of 1932. It should only be pointed out that the brown spots at the horizontal interambulacral sutures are found in the present specimens only at the median end of the sutures, not at the adradial end.

Large globiferous pedicellariæ are not found in the present specimens, as was the case also in the Mauritius specimens. Neither was found the peculiar sort of short-stalked tridentate pedicellariæ, which was found in the Mauritius specimens (*op. cit.*, pl. xii, fig. 4).

This form bears much resemblance to *Stylocidaris albidens* H. L. Clark, and might perhaps equally well be regarded as a variety of that species as of *bracteata*. The matter is comparatively unimportant, the main thing being that it must be kept as a separate variety at least, and cannot simply be referred to either of the two species, *bracteata* or *albidens*.

Stylocidaris lævispina n. sp. (Pl. II, fig. 5 ; Pl. IV, figs. 1, 5 ; Pl. V, fig. 6 ; Pl. VI, figs. 7, 10, 11.)

Occurrence :

St. 24, 9.x.1933, 11° 54′ N., 51° 13′ E., 73–200 m., off Cape Gardafui. 5 specimens.

Descriptive Notes :

H.d. mm.	V.d. mm.	Apical system.	Peristome.	Number of I.A.	Number of A. pro I.A.	Longest spines.
37	26·5	16 mm. (43% h.d.)	15 mm. (40·5% h.d.)	7	11–12	40 mm.
35	23	16 ,, (46% ,,)	15 ,, (43 % ,,)	6	13–14	43 ,,
35	22	15 ,, (43% ,,)	12 ,, (34 % ,,)	6–7	13–14	42 ,,
30	19	14 ,, (47% ,,)	12·5 ,, (41 % ,,)	6	13–15	47 ,,
25	15·5	12 ,, (48% ,,)	11 ,, (44 % ,,)	6	11–12	57 ,,

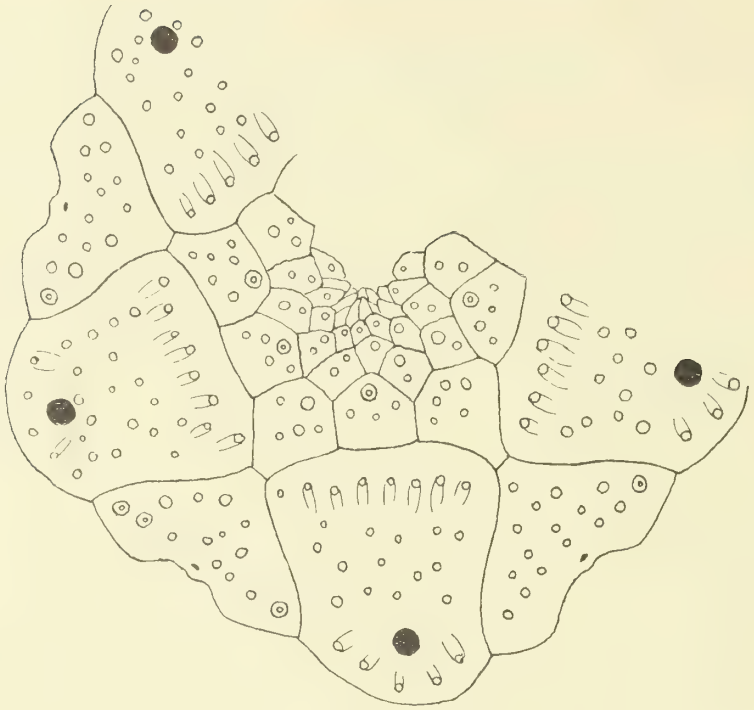
Shape of test low, rounded, more or less flattened on both oral and aboral side, there being, as appears from the measurements, a rather considerable variation in the height. The sides are beautifully arched, the circumference round.

Ambulacra one-third the width of the interambulacra, slightly sinuate, the interporiferous zone only about as broad as a pore-zone. Marginal series of tubercles perfectly regular, the tubercles rather small, not contiguous, separated by a series of small miliary (pedicellariæ-bearing) tubercles. Adradially to the marginal tubercle each plate carries one single secondary tubercle placed at the lower edge of the plate, forming a regular series parallel to the marginal series. The median part of the interporiferous zone naked, but not sunken. The pores are rather large, the wall broad, rising at its upper side into a rather sharp edge, higher than the ridge, which is very inconspicuous (Pl. V, fig. 6).

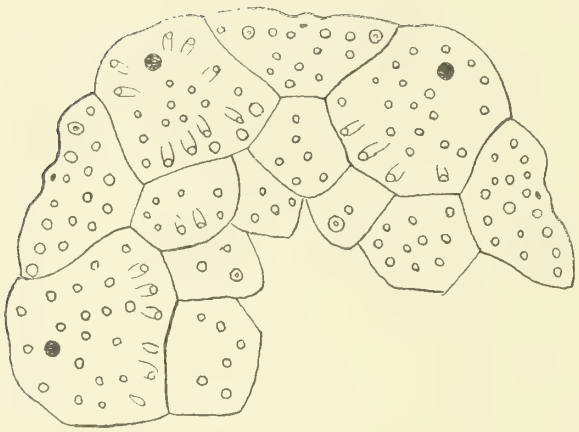
Interambulacra.—Areoles of medium size, not deepened, well separated, except the two lowermost ones, which are confluent. The uppermost, not quite fully formed, areole in one or both series slightly prolonged upwards (effluent). No trace of crenulation on the primary tubercles. The scrobicular tubercles small, and rather widely separated, scarcely larger than the secondary tubercles, which cover the rest of the plate, leaving no naked median line. The median space narrow, only half the width of the areoles.

Apical system varying rather considerably in size, 43–48% of the horizontal diameter. The oculars all insert, more or less broadly (Text-fig. 7 *a*, *b*). Madreporite not enlarged. The apical plates on the whole rather sparingly tuberculated ; the tubercles along the inner edge of the genital plates may be very conspicuously comma-shaped. *Peristome* somewhat smaller than the apical system. There are *c.* 12–13 ambulacral plates in a series, the pores forming a single, straight line. Interradial plates usually 6, in a regular series reaching almost to the mouth edge.

Primary spines from about as long as the horizontal diameter of the test to more than twice that length. They may be slightly fusiform or simply cylindrical, tapering gently to a point. The surface of the shaft is smooth, but with *c.* 15 low, non-serrate, or at most very indistinctly serrate ridges. The space between the ridges very finely striated, without hairs, only with some low, simple prominences (Text-fig. 8). There is a smooth neck of *c* 3 mm. ; the collar is *c.* 1·5 mm., increasing slightly in thickness towards the fairly conspicuous milled ring. The oral primaries are finely ridged on the aboral side, with smooth edges, only slightly widened ; the third is transitional to the ambital spines. *Secondary spines* : The scrobicular spines are *c.* 4 mm. long, not much appressed, they are

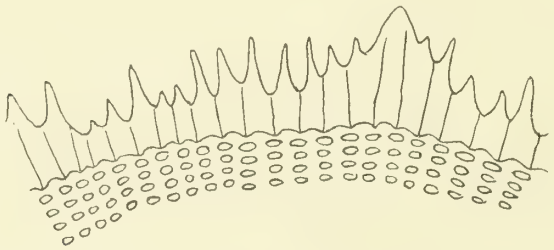


a



b

Text-fig. 7*a*, *b*.—Parts of apical system of *Stylocidaris lævispina*. × 6. Showing variation in the insert condition of the ocular plates.



Text-fig. 8.—Part of transverse section of primary spine of *Stylocidaris lævispina*. × 85.

almost rectangular, somewhat excavated on the outer side. The ambulacral spines more slender, *c.* 3 mm. long. The smaller secondaries erect, pointed, without a glandular ampulla.

Pedicellariæ.—The large globiferous form not observed in any of the specimens. In compensation the small globiferous form is very richly developed, both in numbers and size, some of them, mainly found between the scrobicular spines, reaching a size of 1 mm. length of head. Sometimes the valves are irregular, recalling the curious irregular pedicellariæ found in some species of *Stylocidaris* (*cf.* Monograph Ech. I, p. 361) (Pl. VI, figs. 7, 11). The tridentate pedicellariæ are also very well developed, reaching a size of *c.* 2 mm. length of head. The valves are very slender, joining only at the point (Pl. VI, fig. 10). *Spicules* of the tube-feet and the intestinal wall as usual in *Stylocidaris*.

Colour.—The test with the spines on it is cream-coloured, with the apical system dark brownish, this brownish colour continuing along the ambulacral midline and the midline and horizontal sutures of the interambulacra. The denuded test is white, with a green tinge on the upper interambulacral plates and the interporiferous zone of the ambulacra. Also the ocular plates are whitish, with a green tinge, whereas the genital plates are a dark olive, forming thus a very conspicuous star. Also the periproct is dark olive. The primary spines are light pinkish, with a more or less distinct narrow, dark ring at the limit between collar and shaft. The secondary spines are nearly white, only with an indication of a darker midline.

Biology.—This species is unusual in that its spines are very little infested with foreign organisms ; only some small specimens of a sort of *Vermetus*, a few Serpulid tubes and Foraminifera (*Polytrema*) may be found here and there, the spines in general remaining clean.

Remarks.—This species is evidently very closely related to *Stylocidaris tiara*, but differs markedly from it in the character of the primary spines, which in *St. tiara* have only 8 longitudinal ridges, much stronger developed than in the present species, with 15–16 longitudinal ridges. Also the spines are much more slender and fragile in *tiara* than in the present species. Though not of very great importance this difference forbids identifying the present specimens with *tiara* and necessitates making a separate species of them.

Acanthocidaris curvatispinis (Bell). (Pl. V, fig. 3.)

Acanthocidaris curvatispinis Mortensen, 1928, Monogr. Ech. I, p. 323, pl. lxxxiii, figs. 16–18 ; 1932, New Contrib. Knowl. Cidarids, p. 156, pl. v, figs. 1–5, pl. xi, fig. 4, and pl. xii, fig. 8.

Occurrence :

St. 24, 9.x.1933, 11° 54′ N., 51° 13′ E., 73–200 m., off Cape Gardafui. 1 specimen.

Descriptive Notes.—This specimen is in a very fragmentary condition, completely crushed ; it must have been some 35–40 mm. h.d., thus about half grown. It is rather dark coloured, the secondary spines a brownish-olive. The same colour is found on the denuded test in the ambulacra, in the interporiferous area, whereas the interambulacra are rather dark-greenish. The collar of the primary spines is of an olive colour, with the characteristic series of whitish elevations accompanied by small purple spots.

No large globiferous pedicellariæ found.

The pores differ rather conspicuously from those of the young specimens, as

represented in my paper of 1932, pl. xi, fig. 4, the outer pore being distinctly larger (Pl. V, fig. 3).

Our knowledge of this splendid Cidarid is still unsatisfactory, no adult specimen being as yet available for study. Recently a very fine adult specimen has been taken on a fishing line at Mauritius, off Black River, at a depth of *c.* 200 metres, as I am informed by my friends, Mr. G. Antelme and Major L. Regnard, Port Louis. This, the third adult specimen known, is now in the Museum of Port Louis, Mauritius, being one of the fine treasures of that museum.

Prionocidaris baculosa (Lamarck). Forma typica.

Prionocidaris baculosa Mortensen, 1928, Monogr. Ech. I, p. 439, pl. xlvii, figs. 2, 3, pl. xlviii, fig. 2, etc.

Occurrence :

St. 45, 29.x.1933, 18° 3′ N., 57° 02′ E., 38 m. 4 specimens.

St. 71, 26.xi.1933, 25° 35′ N., 56° 42′ E., 106 m., Gulf of Oman, Hormuz Strait. 2 specimens.

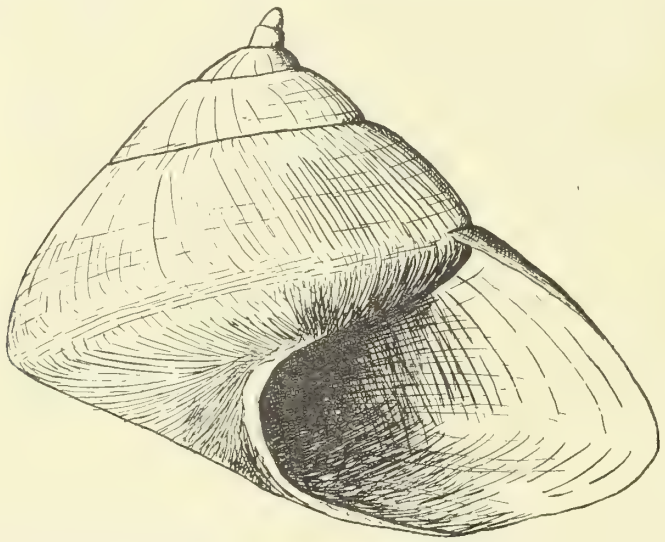
Prionocidaris pistillaris (Lamarck).

Prionocidaris pistillaris Mortensen, 1928, Monogr. Ech. I, p. 452, pls. xlix, l and li, etc.

Occurrence :

St. 24, 9.x.1933, 11° 54′ N., 51° 13′ E., 73–200 m., off Cape Gardafui. 5 specimens.

Descriptive Notes.—These specimens, ranging in size from 32 to 13·5 mm. h.d., are perfectly typical examples of this species, as described in my Monograph. (*loc. cit.*).



Text-fig. 9.—Parasitic gastropod (? *Mucronalia*) from *Prionocidaris pistillaris*. × 15. (H. Fasmer del.)

It may be mentioned that the primary spines of the youngest specimen are fairly distinctly banded with darker and lighter brownish in the distal part. One of the larger specimens, which I have partly denuded, shows scarcely any trace of greenish tint on the aboral side, as otherwise characteristic of the species. In the two smallest specimens tridentate pedicellariæ are well developed; they are very much like those of *Pr. baculosa*.

Genital pores are only beginning to appear in a specimen of 17 mm. h.d.

This species is still known only from the western part of the Indian Ocean and would seem to be characteristic of that area.

I may take the opportunity of mentioning here that a specimen of this species from the coral reef at Inhaca, Delagao Bay (sent me by Prof. C. J. v. d. Horst, Johannesburg) is infested by some specimens of a parasitic Gastropod, which lives in galls in the test. The galls are on the inside, opening to the outside only through a small pore. As seen from Text-fig. 9, representing an adult specimen (it was found dead within the gall), it is a fairly large form of the genus *Stylifer* or *Mucronalia*, characterised by the great width of the test ; evidently it is a new species.

The galls are all of them in the ambulacra. As suggested by Koehler in his description of another parasitic snail, a *Mucronalia*, living on *Stereocidaris indica*, it appears that the parasite enters through the ambulacral pores, thus avoiding the trouble of making for itself the necessary perforation of the test (*cf.* Koehler, " Investigator " Echinoidea, III, p. 137 ; "Anomalies, Irregularités et Deformations du Test chez les Echinides ", 'Ann. Inst. Océanogr.', I, 1924 ; Appendix, p. 441).

Family Echinothuridæ.

Phormosoma bursarium A. Aggassiz.

Phormosoma bursarium A. Agassiz, 1881, " Challenger " Ech., p. 99, pl. x, fig. b.
Phormosoma indicum Döderlein, 1906, Ech. d. deutschen Tiefsee-Exp., p. 130, taf. xv, figs. 1, 2, taf. xxxviii, figs. 2, 3.
Phormosoma bursarium Mortensen, 1935, Monogr. Ech. II, p. 135, pl. ii, fig. 20, pl. iii, figs. 1, 2 and pl. lxxiv, figs. 11–15.

Occurrence :

St. 107, 12.i.1934, 5° 15′ S., 39° 33′ E., 421–457 m., Pemba Strait. 1 specimen, large, fine.

St. 108, 13.i.1934, 5° 18′ S., 39° 24′ E., 786 m., Pemba Strait. 19 specimens, in poor condition.

St. 109, 13.i.1934, 5° 11′ S., 39° 34′ E., 640 m., Pemba Strait. 4 young specimens.

St. 110, 14.i.1934, 5° 04′ S., 39° 15′ E., 329 m., Pemba Strait. 13 specimens, most of them in very poor condition.

St. 115, 15.i.1934, 5° 05′ S., 39° 22′ E., 640–658 m., Pemba Strait. 4 specimens.

St. 122, 22.i.1934, 5° 21′ S., 39° 23′ E., 732 m., Pemba Strait. Numerous specimens, mostly in very poor condition.

St. 145, 31.iii.1934, 4° 59′ S., 73° 16′ E., 494 m., off Maldive Islands. 4 specimens in poor condition.

St. 184, 4.v.1934, 14° 36′ N., 51° 00′ E., 1270 m., Gulf of Aden. 2 specimens.

Descriptive Notes.—These specimens belong to the form described by Döderlein, *op. cit.*, as *Phormosoma indicum*, which, in my opinion (Monograph, *loc. cit.*), represents the typical *Ph. bursarium*. They are nearly all in a very poor state of preservation and do not give occasion for further remarks beyond what is stated in my Monograph. It should be stated that the tridentate perdicellariæ appear to be all of the slender form.

Phormosoma verticillatum Mrtsn. (Pl. VI, fig. 4.)

Phormosoma verticillatum Mortensen, 1904, Echinothurids from Japan and the Ind. Ocean, Ann. Mag. Nat. Hist. (7 ser.), XIV, p. 90, pl. iv, figs. 1, 2, pl. v, figs. 15–17.

Phormosoma adenicum Döderlein, 1906, Ech. d. deutschen Tiefsee-Exp., p. 134, taf. xv, fig. 3, taf. xxxviii, fig. 4.

Phormosoma verticillatum Mortensen, 1935, Monogr. Ech. II, p. 142, pl. iii, figs. 3, 4, pl. iv, fig. 4, pl. lxxiv, figs. 7–10.

Occurrence :

St. 158, 7.iv.1934, 4° 42′ N., 72° 42′ E., 786–1170 m., off Maldive Islands. 1 young specimen, 13 mm. h.d. Identification uncertain.

St. 184, 4.v.1934, 14° 36′ N., 51° 00′ E., 1270 m., Gulf of Aden. 3 specimens.

Descriptive Notes.—One of the specimens is 81 mm. in diameter, thus being considerably larger than any specimen hitherto recorded, and proves that this species may reach about the same size as *Ph. placenta* and *bursarium*, the two other common species of this genus. (Of the third species *Ph. rigidum* we still know only one specimen, the type.) Another specimen, 67 mm. h.d., has kept its shape very beautifully, showing that, as in *Ph. placenta*, the aboral side is low hemispherical, the oral side flat and the edge rather sharp ; the vertical diameter is *c.* 18 mm.

The colour is a dark brownish ; apparently it was darker on the oral side ; the large primary spines of the oral side particularly show traces of having been dark purplish.

The primary spines are all broken, but enough of them remains to show the characteristic whorls of thorns.

The large slender form of tridentate pedicellariæ (*vide* Monograph, II, p. 144, pl. lxxiv, fig. 9) was not found preserved in any of the specimens. The smaller, broad-valved form varies considerably in the shape of the valves, some being much broader than others ; they may also occur in a form with the valves distinctly inrolled in the basal part ; the apophysis is remarkably broad in this form (Pl. VI, fig. 4).

The young specimen from St. 158 is not referable with certainty to this species, though having much the appearance of it. None of the spines show the characteristic verticillation, but a couple of tridentate pedicellariæ seem to be of the long slender type characteristic of *Ph. verticillatum*.

Tromikosoma (*?*) *uranus* (Wyv. Thomson). (Pl. V, fig. 8.)

Hygrosoma uranus Mortensen, 1927, Ech. du " Travailleur " et du " Talisman ", p. 25, pl. i, fig. 1, pl. ii, fig. 1.

Tromikosoma uranus Mortensen, 1935, Monogr. Ech. II, p. 168, pl. vi, figs. 2, 3, pl. lxxv, figs. 19–21.

Occurrence :

St. 133, 15.ii.1934, 1° 26′ S., 66° 34′ E., 3345 m., southern area of Arabian Sea. 2 young specimens, *c.* 40 and *c.* 50 mm. diameter.

Descriptive Notes.—These specimens agree with *Tr. uranus* in regard to the characters of the ambulacra and the pedicellariæ, and it would thus seem quite probable that they are really identical with the said species, in spite of the fact of its not being known hitherto from outside the Atlantic. It is, however, not safe to say definitely that they do belong to *Tr. uranus*, because of the insufficient knowledge we possess of that species, and also because the specimens from the Indian Ocean are only young ones. Also

it seems that the spines are somewhat different, as seen on a comparison of the sections represented here (Text-fig. 10) with that of the typical *uranus* represented in fig. 101, p. 169 of my Monograph. If constant, this difference proves that the form from the Indian Ocean is not identical with the Atlantic *Tr. uranus*—but we do not know how constant and reliable this character is. The only thing that is certain is that the specimens from the Indian Ocean are very closely related to *Tr. uranus* ; whether identical or not cannot be decided from the material at present available.

In the smaller specimen one of the hoofed spines is preserved complete ; Pl. V, fig. 8 shows the shape of the hoof.

The genus *Tromikosoma* was not hitherto known from the Indian Ocean, so, even though the determination of the species is uncertain, the discovery that the genus does occur in the Indian Ocean is of considerable interest.

Text-fig. 10.—Part of transverse section of primary spines of *Tromikosoma* (*?*) *uranus* ; *a*, of an oral, *b*, of an aboral spine. × 200.

Hygrosoma hoplacantha (Wyv. Thomson).

Phormosoma hoplacantha A. Agassiz, 1871, " Challenger " Ech., p. 101, pls. xi, xii, etc.
Hygrosoma æthiopicum Döderlein, 1906, Ech. d. deutschen Tiefsee-Exp., p. 141, taf. xvi, figs. 1–4, taf. xxxix, fig. 2.
Hygrosoma hoplacantha Mortensen, 1935, Monogr. Ech. II, p. 208, pl. xviii, fig. 1, pl. xix, fig. 1, pl. xx, figs. 1, 2, and pl. lxxviii, fig. 2.

Occurrence :

St. 33, 15.x.1933, 13° 41′ N., 48° 17′ E., 1295 m., Gulf of Aden. 5 specimens, in very poor condition.

St. 108, 13.i.1934, 5° 18′ S., 39° 24′ E., 786 m., Pemba Strait. Several young specimens.

St. 122, 22.i.1934, 5° 21′ S., 39° 23′ E., 732 m., Pemba Strait. 12 young and 3 large specimens, *c.* 200 mm. diameter, in very poor condition.

St. 124, 23.i.1934, 5° 39′ S., 39° 39′ E., 914 m., Pemba Strait. 1 specimen (fragments).

St. 143, 30.iii. 1934, 5° 19′ S., 73° 23′ E., 797 m., off Maldive Islands. 3 specimens, in very poor condition.

St. 184, 4.v.1934, 14° 36′ N., 51° 00′ E., 1270 m., Gulf of Aden. 2 specimens.

Descriptive Notes.—As pointed out in my Monograph (pp. 214, 215) there can be no doubt that Döderlein's *Hygrosoma æthiopicum* is identical with *H. hoplacantha*.

As for the specimen from New Amsterdam mentioned there, which Döderlein identified as *Hygrosoma hoplacantha*, the present material does not help us to settle the question of its identity with or distinctness from *hoplacantha*, because, unfortunately, all the larger specimens are in such a poor state of preservation as to be unfit for a more detailed study.

From each of Sts. 62 and 118 there are two small specimens of Echinothurids in such poor state of preservation that it is perfectly hopeless to try to identify them. Presumably they are all of them *Hygrosoma hoplacantha* ; but this cannot be more than a mere guess.

Sperosoma sp.

Occurrence :

St. 118, 17.i.1934, 4° 06′ S., 41° 10′ E., 1798 m., off Mombasa. 2 young specimens, *c.* 15 and *c.* 25 mm. diameter.

Descriptive Notes.—Both these specimens are in very poor condition, with hardly a small piece of spine and not a pedicellaria left. Identification of the species would perhaps have been possible if the specimens were in perfect state of preservation ; as they are, identification as to species is out of the question. It can only be said that presumably they belong to one of the three species known from the Indian Ocean : *biseriatum* Döderlein, *durum* Döderlein, or *armatum* Koehler.

Arœosoma alternatum Mrtsn.

Arœosoma coriaceum Döderlein, 1906, Ech. d. deutschen Tiefsee-Exp., p. 122, taf. xiv, fig. 1, taf. xxxviii, fig. 1. (*Non Arœosoma coriaceum* (A. Agassiz).)
Arœosoma alternatum Mortensen, 1935, Monogr. Ech. II, p. 270.

Occurrence :

St. 107, 12.i.1934, 5° 15′ S., 39° 33′ E., 421–457 m., Pemba Strait. 3 large specimens, *c.* 170 mm. diameter.

St. 110, 14.i.1934, 5° 04′ S., 39° 15′ E., 347–384 m., Pemba Strait. 1 large specimen.

St. 123, 22.i.1934, 5° 19′ S., 39° 32′ E., 255–366 m., Pemba Strait. 1 specimen.

These specimens are in perfect agreement with the description, given by Döderlein (*op. cit.*), under the erroneous name of *Arœosoma coriaceum*, of the single specimen taken by the " Valdivia " off the Somali coast.

To the remarks given in my Monograph (*loc. cit.*) I have only to add that in one of the specimens from St. 107 the outer series of interambulacral tubercles on the oral side is an alternating double series, there being here a tubercle on each plate, but so that on every other plate the tubercle is close to the adradial edge, on the alternating plates farther inwards.

Dactylous pedicellariæ have not been observed on any of the specimens ; this is, however, no proof of their non-existence in this species, since in four of the specimens in hand the aboral side is almost totally naked ; only in the specimen from St. 110 are the spines of the aboral side fairly well preserved, but, unfortunately, this specimen has been forced down into too small a jar, so that a thorough examination of it was made impossible.

Asthenosoma varium Grube.

Asthenosoma varium Mortensen, 1935, Monogr. Ech. II, p. 280, pls. lv–lviii, pl. lxi, figs. 1–6, and pl. lxii, figs. 1, 2, etc.

Occurrence :

St. 10, 17.ix.1933, 13° 31′ N., 42° 31′ E., 55 m., Southern part of Red Sea. 1 young specimen, 20 mm. diameter.

Descriptive Notes.—Although in poor condition this specimen can be identified with certainty as being a young *Asth. varium*, the few spines left being of the characteristic banded appearance.

The species having previously been found by Dr. Dolfuss in the Gulf of Suez (*cf.* Monograph, p. 287) there can be no doubt of its occurring all over the Red Sea at suitable depths.

Family Salenidæ.

Salenocidaris miliaris var. *indica* n. var. (Pl. VI, fig. 9.)

Occurrence :

St. 155, 5.iv.1934, 4° 31′ N., 72° 38′ E., 2249 m., off Maldive Islands. 1 specimen.

St. 162, 10.iv.1934, 8° 08′ N., 72° 58′ E., 1829–2051 m., off Minikoi. 2 specimens.

Descriptive Notes.—This form belongs to the group *S. profundi* (Duncan)—*S. miliaris* (A. Agassiz), with which it agrees in Oc. I being broadly insert. It seems to me to stand nearer to *miliaris*, on account of its ambulacral pores being larger and its primary spines being more conspicuously verticillate than in *profundi* and more like those of *miliaris* ; but, on the other hand, it agrees more with *profundi* in the gradual passage from the adoral to the ambital interambulacral tubercles. In regard to the shape of the quadridentate pedicellariæ it differs from both of the said species (Pl. VI, fig. 9 to compare Monograph II, pl. lxxxvi, figs. 2 and 39). To identify these specimens directly with any of the two species I think unjustifiable, but as they are very closely related to them, I think it the right course to designate them as a variety of one of them.

A more detailed description seems unnecessary, the 4-dentate pedicellariæ being, as a matter of fact, the only noteworthy distinguishing character. I have not observed these pedicellariæ on the larger specimen from St. 162 (14 mm. h.d.), whereas they are well developed on the smaller one (8 mm. h.d.). In this latter specimen there are some tridentate pedicellariæ also on the buccal plates. Claviform pedicellariæ were not observed in any of the specimens.

On the specimen from St. 155 (which is badly crushed) a number of yellow egg-capsules are found attached all over the test ; it is evident that they are of some parasitic snail, which has probably been attached to some of the lacking parts of the test.

On the larger specimen from St. 162 the secondary spines are rather irregular and, particularly on the adapical part, somewhat thickened and more or less trumpet-shaped. It seems quite evident that this is something pathological, and this specimen therefore cannot be made the type of the variety ; in the two other specimens the secondary spines are normal, very much like those of *miliaris*.

One might rather have expected these specimens to be identical with the form described by Döderlein from the " Valdivia " collection as *S. hastigera*, also taken off the Maldive Islands ; this would seem the more probable, since the tridentate pedicellariæ are very much alike (*cf.* 'Ech. d. deutschen Tiefsee-Exped.', taf. xlv, fig. 3, d). But in Döderlein's specimen Oc. I is exsert, whereas in the present specimens, also in the smallest one, it is

broadly insert. Judging from what is known at present this is a character of primary importance in *Salenocidaris*, and thus the present specimens cannot be regarded as identical with the "Valdivia" specimen. Perhaps, when once a rich material of these forms becomes available, it will be found that the said character of Oc. I is not reliable, and if so, there can hardly be any doubt about the identity of the present specimens with the "Valdivia" specimen—but for the present we are not justified in regarding them as identical.

Family Arbaciidæ.

Cœlopleurus Maillardi (Michelin).

Cœlopleurus Maillardi Mortensen, 1935, Monogr. Ech. II, p. 627, pl. lxvii, fig. 3, pl. lxviii, fig. 4, and pl. lxix, figs. 1–3, etc.

Occurrence :

St. 24, 9.x.1933, 11° 57′ N., 51° 13′ E., 73–200 m., off Cape Gardafui. 1 young specimen.

Descriptive Notes.—This specimen, 13 mm. h.d., with genital pores not formed as yet, is perfectly typical. It may be mentioned that the genital plates have several irregular not distinctly radiating elevations in the proximal part, but no real tubercles; their appearance is thus rather different from that shown in fig. 369*c*, p. 632, of my Monograph. But this is clearly only a difference due to age, the specimen from which the said figure was drawn being 21 mm. h.d., thus nearly twice as big as the present specimen. A full-grown specimen of this species still remains a desideratum.

Family Diadematidæ.

Diadema Savignyi Michelin.

Diadema Savignyi Mortensen, 1904, "Siam" Ech., p. 16; A. Agassiz and H. L. Clark, 1908, Hawaiian Echini. Salenidæ . . . Diadematidæ, p. 114; H. L. Clark, 1925, Cat. Rec. Sea-Urchins Brit. Mus., p. 43.

Occurrence :

St. 27, 12.x.1933, 11° 57′ N., 50° 35′ E., 37–91 m., off Cape Gardafui. 2 young specimens.

Descriptive Notes.—The arrangement of the (faded) blue colour in a distinct ring on the apical system, and in two continuous lines down along the midline of the interambulacra seems to make the identification as *D. Savignyi* certain, in spite of the absence of the characteristic tridentate pedicellariæ.

Chætodiadema africanum H. L. Clark.

Chætodiadema africanum H. L. Clark, 1924, Echinoderms S. African Fisheries and Mar. Biol. Survey, I, Sea-Urchins (Echinoidea), p. 2, pl. i; 1925, Cat. Rec. Sea-Urchins Brit. Mus., p. 49.

Occurrence :

St. 106, 12.i.1934, 5° 39′ S., 39° 16′ E., 183–194 m., Pemba Strait. 5 young specimens.

Descriptive Notes.—These specimens, ranging from *c.* 18 to 9 mm. horizontal diameter, are all in a poor state of preservation, more or less broken, with hardly a pedicellaria and only very few broken spines left. But they have the very characteristic design, a narrow, continuous reddish (in life probably bluish) line along each side of the naked interambulacral space on the aboral side; also a conspicuous spot on each genital

plate. The largest specimen has a faint pinkish, the others a faint greenish, tint, much as described by Clark (*op. cit.*, 1925). I have no doubt of the correctness of identifying these specimens as *Ch. africanum.*

The largest specimen is still without trace of the genital pores ; the youngest specimen has already all the oculars insert, though rather narrowly so.

Echinothrix calamaris (Pallas).

Echinothrix calamaris, H. L. Clark, 1925, Cat. Rec. Sea-Urchins Brit. Mus., p. 44.

Occurrence :

St. 27, 12.x.1933, 11° 57′ N., 50° 35′ E., 37–91 m., off Cape Gardafui. 1 small specimen, in poor condition.

Centrostephanus nitidus Koehler.

Centrostephanus nitidus Koehler, 1927, Echinoidea of the Indian Museum, III, p. 53, pl. ix, figs. 4–10, pl. x, figs. 1, 3, 4, 8, 9, and pl. xxvi, fig. 2.

Occurrence :

St. 157, 6.iv.1934, 4° 44′ N., 72° 55′ E., 229 m., off Maldive Islands. Several specimens.

Descriptive Notes.—These specimens are all of very nearly the same size, *c.* 35 mm. horizontal diameter. They conform very well with the careful description given by Koehler, and call for no further descriptive remarks at the present occasion (whereas a few additional notes will be given in Part III of my Monograph).

The fact that so many specimens of the same size were taken in one haul—and at no other station—and that Koehler's specimens were all from a single station—indicates that this species occurs in schools, as is the case with *Diadema.*

Family Micropygidæ.

Micropyga violacea de Meijere.

Micropyga violacea de Meijere, 1904, " Siboga " Ech., p. 63, taf. iv, figs. 29, 30, taf. xv, figs. 232–234.

Occurrence :

St. 109, 13.i.1934, 5° 11′ S., 39° 34′ E., 640 m., Pemba Strait. 3 specimens.

Descriptive Notes.—These specimens are fairly well preserved, particularly one of them, which shows a fair number of the club-shaped oral primary spines so characteristic of the genus *Micropyga.*

The species was not hitherto known from the Indian Ocean. The finding of it close to the African coast suggests that it may be distributed all over the tropical part of the Indian Ocean. The specimens differ from those of the Malayan region in the apical system being more sunken than I have seen in any Malayan specimen. If this proves to be a constant difference, there may be reason to distinguish the Indo-African specimens as a separate variety ; as there seems to be no other differences there can hardly be sufficient reason for distinguishing the East African specimens as a separate species.

Micropyga tuberculata A. Agassiz.

Micropyga tuberculata A. Agassiz, 1881, " Challenger " Ech., p. 68, pl. vii ; Döderlein, 1906, Ech. d. deutschen Tiefsee-Exped., p. 169, taf. xxi, fig. 4, taf. xlii, figs. 1–6, taf. lxiii, figs. 1–8 and taf. lxiv, fig. 1.

Occurrence :

St. 123, 22.i.1934, 5° 19′ S.,39° 32′ E., 256–366 m., Pemba Strait. 1 specimen, in very poor condition.

Descriptive Notes.—The species was taken by the " Valdivia " in the Siberut Strait at Sumatra, being otherwise unknown from the Indian Ocean. The finding of it at the African east coast indicates that, like *M. violacea*, it must occur all over the Indian Ocean, in the tropical parts ; one can only wonder that the two species were not found by the " Investigator ".

Family Aspidodiadematidæ.

Plesiodiadema amphigymnum (de Meijere) (? Var.).

Occurrence :

St. 162, 10.iv.1934, 8° 08′ N., 72° 58′ E., 1829–2051 m., off Minikoi. 1 specimen.

Descriptive Notes.—The single specimen, 11 mm. horizontal diameter, is in poor condition, and does not allow a definite identification. It agrees with *Plesiodiadema amphigymnum* of the Malay Archipelago in the important character of the buccal plates carrying no spines, in the characters of the test and spines, as also in the presence of ophicephalous pedicellariæ without stalk-glands. But it differs conspicuously from the typical *amphigymnum* in the strong development of the periproctal plates, there being a circle of seven rather large plates round the anus and some small plates outside this circle, whereas the typical *amphigymnum* has the periproct almost naked. Unfortunately tridentate pedicellariæ are entirely lacking in the specimen of the Murray Expedition. As these pedicellariæ, both of the coarse and the slender type, afford important specific characters within the family of the Aspidodiadematids, their absence here deprives us of an important clue to settling the question whether this specimen represents only an individual, or a local variation of *Pl. amphigymnum*, or perhaps represents a closely related, but distinct species. Fresh material is needed for settling the question.

Plesiodiadema molle (Döderlein).

Dermatodiadema molle Döderlein, 1906, Ech. d. deutschen Tiefsee-Exped., p. 160, taf. xx, figs. 4, 5, taf. xli, fig. 1.

Occurrence :

St. 133, 15.ii.1934, 1° 26′ S., 66° 35′ E., 3385 m., southern area of the Arabian Sea. 1 specimen.

The specimen is in exceedingly poor condition, much broken. There is, however, no doubt about its being identical with the specimens of *Pl. molle*, taken by the " Valdivia " between the Maldives and the Chagos Archipelago, thus in about the same area, and also at about the same depth (2919 m.).

Family Temnopleuridæ.

Salmacis erythracis H. L. Clark.

Salmacis erythracis H. L. Clark, 1912, Hawaiian Echini. Pedinidæ . . . Echinometridæ, p. 315, pl. cxi, figs. 4–6 ; 1925, Cat. of the Rec. Sea-Urchins Brit. Mus., p. 86.

Occurrence :

St. 27, 12.x.1933, 11° 57′ N., 50° 35′ E., 37–91 m. off Cape Gardafui. Several specimens, ranging in size from 38 to 27 mm. horizontal diameter.

The characteristic red colour of the secondary spines more or less developed, but there is no doubt that these specimens all belong to the species *erythracis*, characteristic of the western part of the Indian Ocean, not to *S. Dussumieri*, which is not known from this region.

Temnopleurus Reevesii (Gray).

Temnopleurus Reynaudi A. Agassiz, 1872, Revision of the Echini, p. 461, pl. viii, figs. 22–24, pl. viiia, figs. 6, 7. (*Non Temnopleurus Reynaudi* L. Agassiz.)

Temnopleurus Reevesii Mortensen, 1904, "Siam" Echinoidea, p. 62, pl. vi, figs. 3, 10, 12, pl. vii, fig. 37; H. L. Clark, 1925, Cat. Rec. Sea-Urchins Brit. Mus., p. 81.

Occurrence:

St. 24, 9.x.1933, 11° 54′ N., 51° 13′ E., 73–200 m., off Cape Gardafui. 1 young specimen.

Although the colour of this specimen is more green than usual, there can be no doubt that it is really *T. Reevesii*. The species having been found also off the Natal coast and south of the Agulhas Bank, this new locality indicates that it must occur all along the East African coast, in spite of its having been so rarely recorded from there. Also from the Indian Ocean in general it is only rarely recorded, *e. g.* it has not been taken by the "Investigator".

Temnopleurus apodus (A. Agassiz & H. L. Clark).

Genocidaris apoda H. L. Clark, 1912, Hawaiian Echini. Pedinidæ . . . Echinometridæ, p. 297, pl. xciii, figs. 16, 17; pl. c, figs. 1–3.

Occurrence:

St. 106, 12.i.1934, 5° 38′ 54″ S., 39° 15′ 42″ E., Pemba Strait, 212 m. 5 specimens.

This species has till now been recorded only from the Japanese seas. I have, however, taken specimens at the Kei Islands (1922), and in the Bali Sea (1929). The occurrence in the Pemba Strait is proof that it must be distributed all over the Indian Ocean, in the warmer regions and at suitable depths. That it has nothing to do with the genus *Genocidaris*, but must be referred to the genus *Temnopleurus*, close to the species *T. Reevesii*, will be shown in the forthcoming Vol. III of my Monograph of the Echinoidea.

Temnotrema siamense (Mrtsn.).

Pleurechinus siamensis Mortensen, 1904, "Siam" Echinoidea, p. 79, pl. i, figs. 2, 7, 11, 20, pl. ii, figs. 2, 9, 14, 15, 22, pl. vi, figs. 16, 36, and pl. vii, figs. 14, 44, 53.

Temnotrema siamensis H. L. Clark, 1912, Hawaiian Echini. Pedinidæ . . . Echinometridæ, p. 318; 1925, Cat. Rec. Sea-Urchins Brit. Mus., p. 92.

Temnotrema siamense Koehler, 1927, "Investigator" Echinoidea, III, p. 93, pl. xiv, figs. 11, 14.

Occurrence:

MB. IIc, 28.x.1933, 29 m., S. Coast of Arabia, off Kuria Muria Is. 2 specimens.

St. 27, 12.x.1933, 11° 57′ N., 50° 39′ E., 37–91 m., off Cape Gardafui. 1 specimen.

St. 111, 14.i.1934, 5° 04′ S., 39° 14′ E., 73–165 m., Pemba Strait. 1 specimen.

Descriptive Notes.—The specimen from the Pemba Strait is unusually large, 11 mm. horizontal diameter (12 mm. being the record size). It is light cream-coloured and looks rather unusually short-spined, which is due to the fact that the primary spines have been damaged in one way or another and then regenerated, though not quite normally;

the point of these spines therefore does not show the little terminal swelling characteristic of *T. siamense*; still I see no reason to doubt that it really belongs to this species, so variable in regard to colour.

The specimen from St. 27 is of a beautiful red colour, and belongs to the var. *pulchellum*.

The species was till now not known to occur on the East African coast; but there can be no doubt that it will prove to be widely distributed all along the coasts of the Indian Ocean within the tropical region.

Temnotrema scillæ (Mazzetti).

Pleurechinus scillæ Mortensen, 1904, "Siam" Echinoidea, p. 86, pl. i, figs. 9, 10, 17, 18, pl. ii, figs. 4, 10, 12, 13, pl. vi fig. 13 and pl. vii, fig. 25.

Temnotrema scillæ H. L. Clark, 1912, Hawaiian Echini. Pedinidæ . . . Echinometridæ, p. 318; 1925, Cat. Rec. Sea-Urchins Brit. Mus., p. 91; Koehler, 1927, "Investigator" Echinoidea, III, p. 92, pl. xiv, fig. 12.

Occurrence:

St. 45, 29.x.1933, 18° 03′ N., 57° 02′ E., 38 m., off the S. Coast of Arabia. 9 specimens.

One of the specimens is broken, two are naked tests only, without the apical system; the main characters of the species being found only in the spines and the apical system, the identification of these two specimens cannot be quite definite, but there is, of course, no reason to doubt that they are of the same species as the other specimens together with which they were found.

Prionechinus Agassizi Wood-Mason & Alcock.

Prionechinus Agassizi Wood-Mason & Alcock, 1891, Results of Deep-sea Dredging, 1890–91 ("Investigator"), Ann. Mag. Nat. Hist. (6), VIII, p. 441; Döderlein, 1906, Ech. d. Deutschen Tiefsee-Exped., p. 194, taf. xxiv, fig. 1, taf. xxv, fig. 7, taf. xlvi, fig. 1; H. L. Clark, 1912, Hawaiian Echini. Pedinidæ . . . Echinometridæ, p. 308; 1925, Cat. Rec. Sea-Urchins Brit. Mus., p. 78; Koehler, 1927, "Investigator" Echinoidea, III, p. 89, pl. xv, figs. 1, 2.

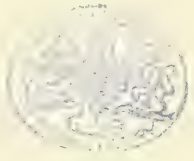
Occurrence:

St. 107, 12.i.1934, 5° 15′ 30″ S., 39° 33′ E., 421–457 m., Pemba Strait. 2 specimens, of 5 and 4 mm. diameter.

St. 109, 17.i.1934, 5° 11′ S., 39° 34′ E., 640 m., Pemba Strait. 1 specimen, 3 mm. diameter.

Descriptive Notes.—The largest specimen carries a parasitic gastropod (*Mucronalia*) on the aboral side. The fact that the apical system is somewhat elevated in this specimen is no doubt an anomaly due to the parasite, the same anomalous elevation of the aboral part of the test being also found in specimens of *Salmacis* infested with this parasitic Gastropod.

The youngest specimen has still only one tube-foot in each pair of buccal plates. In the two specimens from St. 107 the mouth is widely open, so that one looks directly into the œsophagus. In the largest specimen the buccal tube-feet are quite conspicuous on account of the sucking disc being brownish; also the other tube-feet show a faint indication of the same colour.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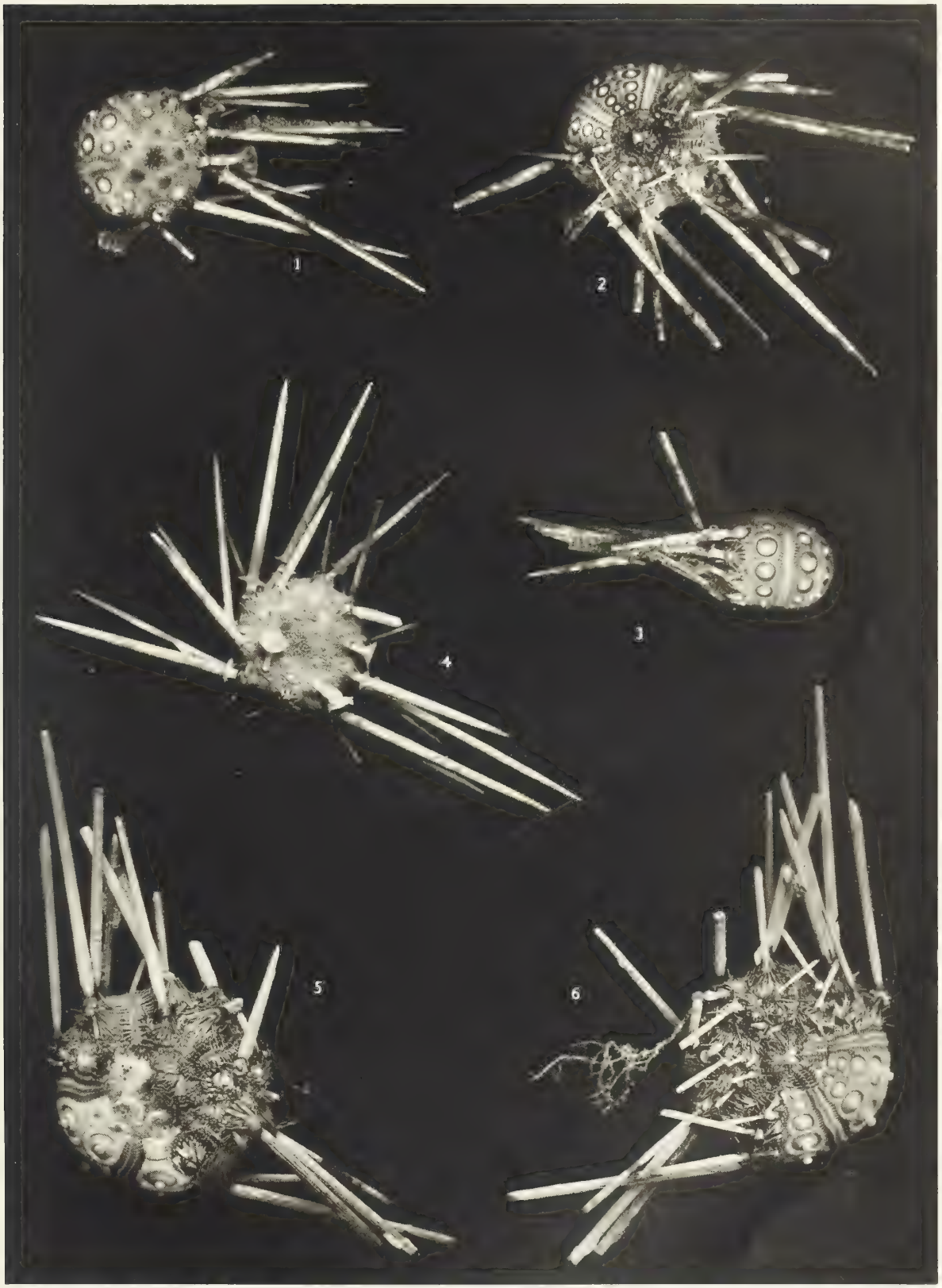
DESCRIPTION OF PLATE I.

Fig. 1.—*Goniocidaris indica* ; partly denuded. Aboral side.
Fig. 2.—*Goniocidaris indica* ; partly denunded. Oral side.
Fig. 3.—*Goniocidaris indica* ; partly denuded. Side view.
Fig. 4.—*Goniocidaris indica.* Aboral side.
Fig. 5.—*Cidaris mabahissæ* ; partly denuded. Aboral side.
Fig. 6.—*Cidaris mabahissæ* ; partly denuded. Oral side.

All figures natural size.



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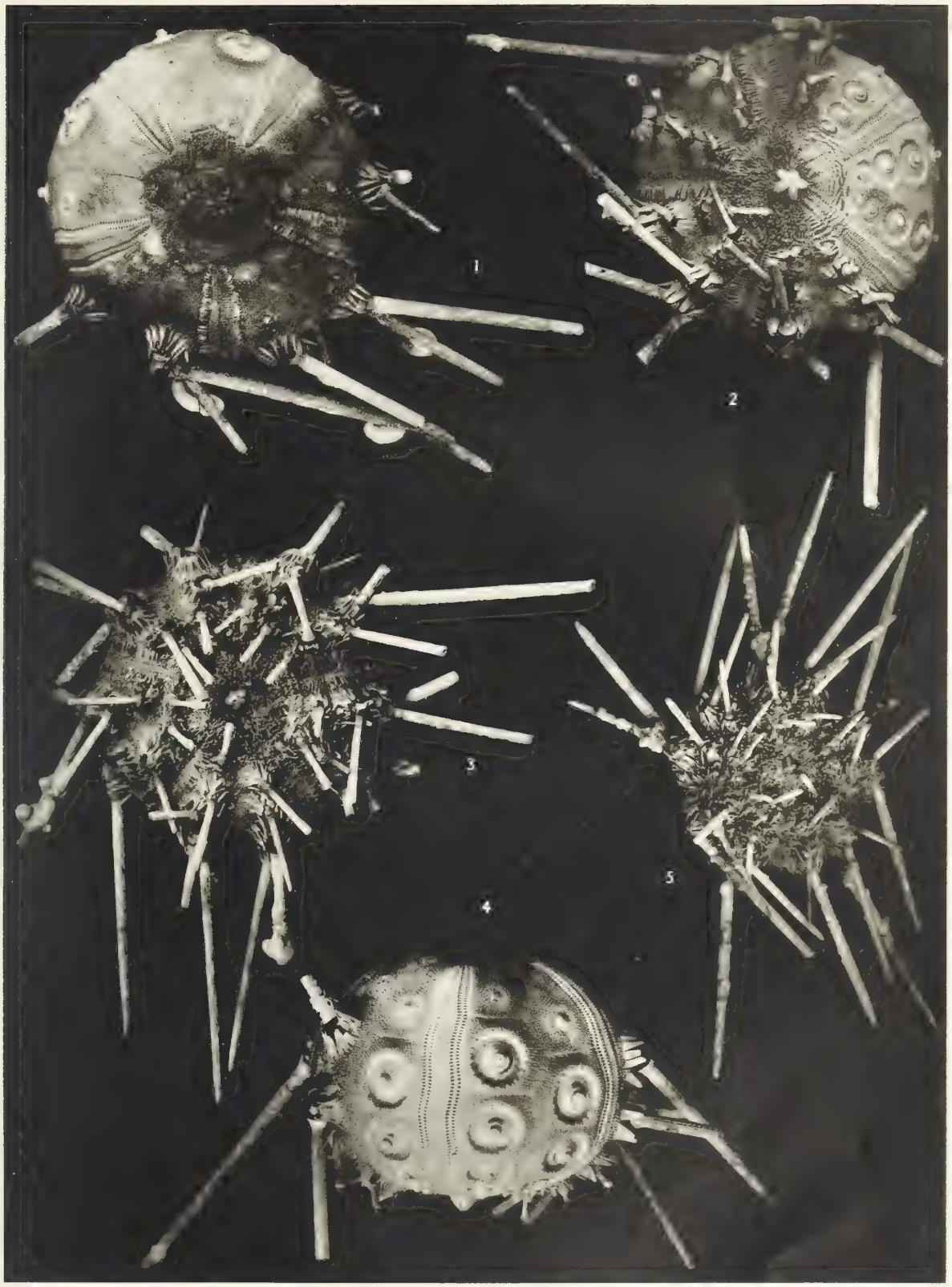
DESCRIPTION OF PLATE II.

FIG. 1.—*Stereocidaris reducta* ; partly denuded. Aboral side.
FIG. 2.—*Stereocidaris reducta* ; partly denuded. Oral side.
FIG. 3.—*Stereocidaris reducta.* Oral side.
FIG. 4.—*Stereocidaris reducta* ; partly denuded. Side view.
FIG. 5.—*Stylocidaris lævispina.* Oral side.

All figures natural size.



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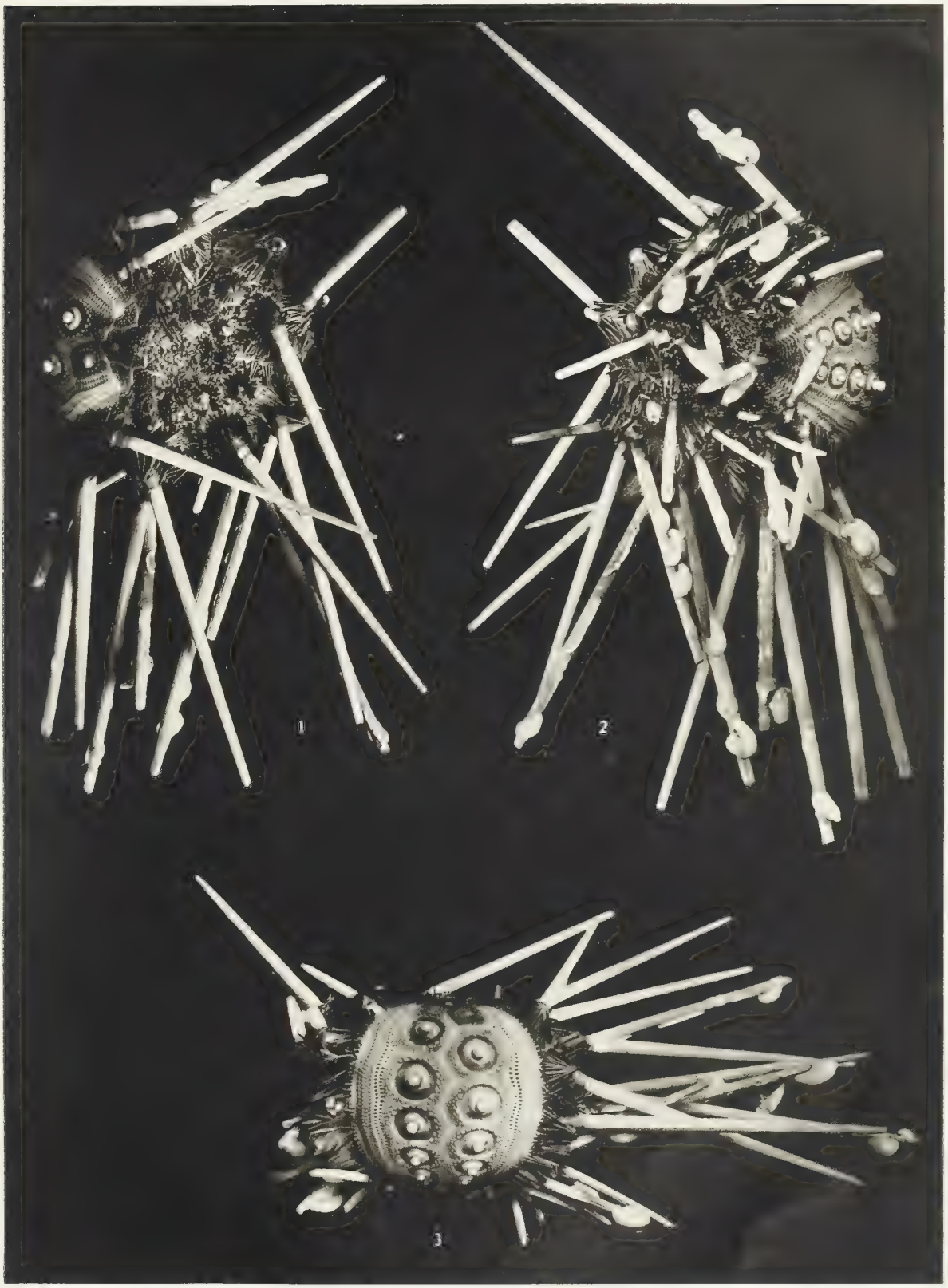
DESCRIPTION OF PLATE III.

FIG. 1.—*Lissocidaris fusca.* Aboral side.
FIG. 2.—*Lissocidaris fusca.* Oral side.
FIG. 3.—*Lissocidaris fusca.* Side view.

All figures natural size.



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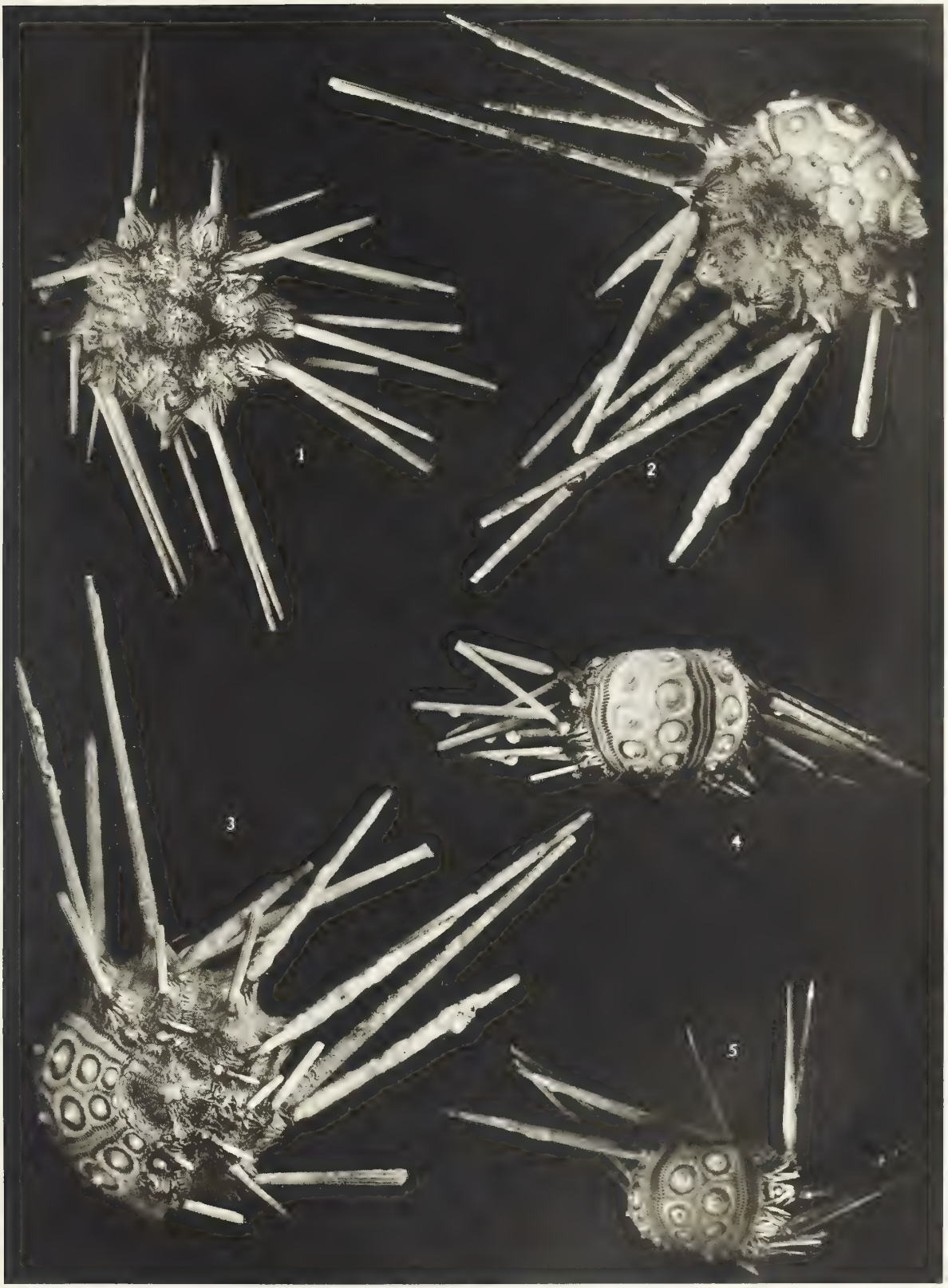
DESCRIPTION OF PLATE IV.

FIG. 1.—*Stylocidaris lævispina.* Aboral side.
FIG. 2.—*Stereocidaris squamosa* ; partly denuded. Aboral side.
FIG. 3.—*Stereocidaris squamosa* ; same specimen. Oral side.
FIG. 4.—*Cidaris mabahissæ ;* partly denuded. Side view.
FIG. 5.—*Stylocidaris lævispina* ; partly denuded. Side view.

All figures natural size.



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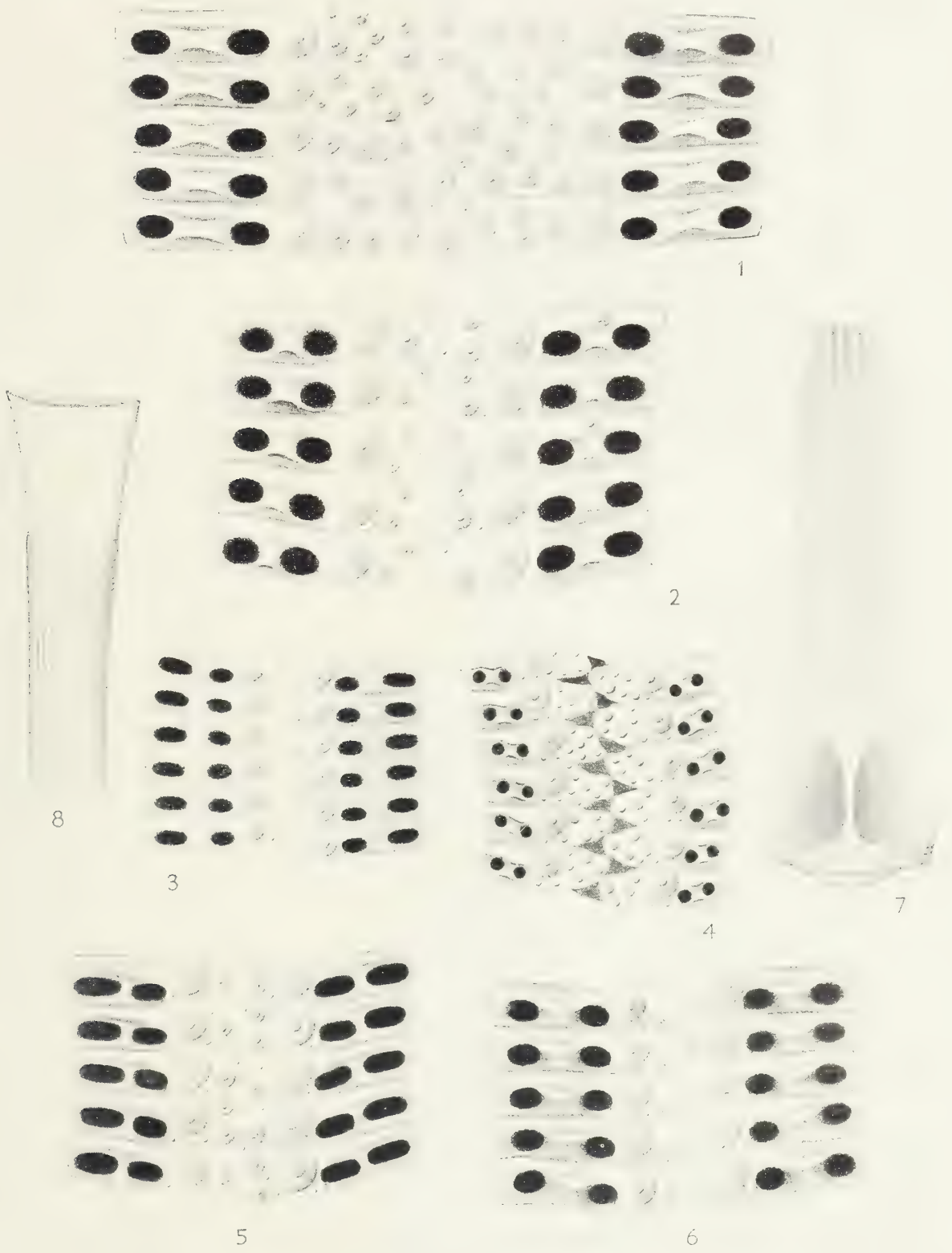
DESCRIPTION OF PLATE V.

FIG. 1.—Part of ambulacrum of *Stereocidaris reducta*. × 12.
FIG. 2.— ,, ,, *Lissocidaris fusca*. × 12.
FIG. 3.— ,, ,, *Acanthocidaris curvatispinis*. × 12.
FIG. 4.— ,, ,, *Goniocidaris indica*. × 12.
FIG. 5.— ,, ,, *Cidaris mabahissæ*. × 12.
FIG. 6.— ,, ,, *Stylocidaris lævispina*. × 12.
FIG. 7.—Valve of large tridentate pedicellaria of *Goniocidaris indica*. × 85.
FIG. 8.—Terminal part of primary oral spine of *Tromikosoma (?) uranus*. × 23.



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DESCRIPTION OF PLATE VI.

FIG. 1.—Valve of tridentate pedicellaria of *Lissocidaris fusca.* × 65.
FIG. 2.— ,, large globiferous pedicellaria of *Lissocidaris fusca.* × 75.
FIG. 3.—Large globiferous pedicellaria of *Cidaris mabahissæ.* × 45.
FIG. 4.—Valve of tridentate pedicellaria of *Phormosoma verticillatum.* × 85.
FIG. 5.— ,, large globiferous pedicellaria of *Cidaris mabahissæ.* × 75.
FIG. 6.— ,, small globiferous pedicellaria of *Lissocidaris fusca.* × 85.
FIG. 7.— ,, globiferous pedicellaria of *Stylocidaris lævispina.* × 60.
FIG. 8.— ,, tridentate pedicellaria of *Cidaris mabahissæ.* × 45.
FIG. 9.— ,, tetradactylous pedicellaria of *Salenocidaris miliaris indica.* × 85.
FIG. 10.— ,, tridentate pedicellaria of *Stylocidaris lævispina.* × 60.
FIG. 11.— ,, small globiferous pedicellaria of *Stylocidaris lævispina.* × 60.
FIG. 12.— ,, ,, ,, ,, *Cidaris mabahissæ.* × 75.
FIG. 13.— ,, ,, ,, ,, *Cidaris mabahissæ.* × 85.
FIG. 14.— ,, ,, ,, ,, *Stereocidaris reducta.* × 85.
FIG. 15.—Large globiferous pedicellaria of *Stereocidaris reducta.* × 85.
FIG. 16.—Valve of tridentate pedicellaria of *Stereocidaris reducta.* × 85.
FIG. 17.— ,, globiferous pedicellaria of *Goniocidaris indica ;* from the inside. × 165.
FIG. 18.— ,, ,, ,, *Goniocidaris indica ;* side view. × 165.
FIG. 19.—Two-valved large globiferous pedicellaria of *Lissocidaris fusca.* × 65.

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BRITISH MUSEUM (NATURAL HISTORY)

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OPHIUROIDEA

BY

HUBERT LYMAN CLARK

(*Museum of Comparative Zoölogy, Cambridge, Mass., U.S.A.*)

WITH SIXTY-TWO TEXT-FIGURES

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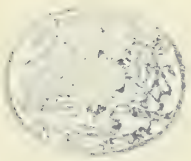


OPHIUROIDEA

BY

HUBERT LYMAN CLARK

(Museum of Comparative Zoölogy, Cambridge, Mass., U.S.A.)

WITH SIXTY-TWO TEXT-FIGURES.

The British Museum, through Dr. W. T. Calman, has done me the honour of asking me to prepare a report on the collection of brittle-stars (Ophiuroidea) made by the John Murray Expedition to the Indian Ocean in 1934. The preparation of such a report has proved both more interesting and more time-consuming than had been anticipated; interesting because the area in which the collection was made has been a veritable *terra incognita*, so far as the ophiurans were concerned; time-consuming as the number of species represented was greater, and the proportion of undescribed forms much greater, than was expected. Apparently the conditions in the north-western Indian Ocean are very favourable to brittle-star life and have resulted in a large and varied ophiuran fauna.

The collection consists of 2261 specimens, representing 102 species of 42 genera. While these are distributed in 11 families, 71 of them belong to the families Ophiacanthidæ, Amphiuridæ and Ophiolepididæ; almost one-third of the species (31 to be exact) are members of this last-named family. Of the 42 genera recognized, no fewer than 6 are groups here named for the first time. No one of these is formed by the breaking up of a previously known genus, but each is needed to accommodate an ophiuran, with such a striking character or such an unusual combination of characters, that a new generic name seemed advisable, if not positively required. Half of these new genera are Amphiuridæ and half are Ophiolepididæ. All but one are monotypic; that one contains two species, but one of the two is represented by only two specimens, and the other is based on a single small individual. Only one of the new genera is represented by a really adequate amount of material. It is, of course, regrettable that so many new groups rest on such slight foundation, but it is the unescapable penalty of having to report on a collection made in a little-known area by an expedition to which the collecting of ophiurans was but incidental to its main purpose.

Of the 102 species, exactly one-third (34) are here named and described for the first time. As would naturally be expected, the bulk of these new forms are Amphiurids (12 species), or Ophiolepids (11 species), but 5 are Ophiacanthids. It is regrettable that 5 new species must be added to the already over-burdened genus Amphiura, but it is hoped the descriptions and figures are adequate, not only for their recognition, but for their proper disposition when the dismemberment of Amphiura takes place.

It is, of course, necessary to assume that the 34 new species are endemic, although it is probable, if not certain, that the range of many will prove to extend far to the south and east of the area explored by the "Mabahiss". The geographical relationships of the 68 previously known species are of much interest as indicating the probable sources from which the fauna has been derived. There follows, therefore, a list of the stations where ophiurans were taken, arranged according to the geographical areas recognized in the reports of the Expedition. A brief discussion of the species involved is given in connection with each area.

LIST OF STATIONS WHERE OPHIURANS WERE TAKEN, ARRANGED ACCORDING TO AREAS.*

Red Sea.

September 17th, 1933 :

St. 10 ; 55 m. *Ophiothrix otiosa, Placophiothrix purpurea.*

St. MB I ; 26–29 m. **Amphiura dejectoides,** *Ophiactis* **hexacantha,** *plana, savignyi* and **versicolor,** *Ophiothrix demessa* and *otiosa, Placophiothrix purpurea, Ophiotrichoides propinqua, Ophiurodon cupidum, Ophiura kinbergi.*

May 16th and 17th, 1934 :

St. 206 ; 256 m. *Amphioplus hastatus.*

St. 208 ; 732–805 m. *Ophiocirce inutilis.*

Of these 13 species, only 3 are new, and one of these (*Ophiactis hexacantha*) was also taken at the Maldives. Of the remaining 10 species, 5 are widely distributed in the Indo-Pacific region, 4 others are East Indian, but one (*Amphioplus hastatus*) was known to reach Mozambique and another (*Placophiothrix purpurea*) Madagascar. The single remaining species (*Ophiothrix otiosa*) was known only from the Malabar coast of India. Only 2 are from deep water (exceeding 200 m.). It is notable that only one of the 13 species was taken in the Suez Canal by the 1924 Cambridge Expedition (see Mortensen, 1926), and this was the ubiquitous *Ophiactis savignyi.*

Gulf of Aden.

September 21st, 1933 :

St. 16 ; 186 m. **Amphioncus platydiscus.**

October 9th–16th, 1933 :

St. 24 ; 73–200 m. *Ophiacantha durbanensis* and *pentagona,* **Amphiura crypta,** *Ophiactis plana, Placophiothrix aristulata, infirma* and *purpurea.*

St. 25 ; 620 m. *Ophiacantha pentagona, Placophiothrix aristulata, Amphiophiura paupera.*

St. 26 ; 2312 m. *Ophiacantha vorax, Bathypectinura conspicua,* **Ophiuraster perissus,** *Ophiura irrorata, Ophiomusium altum, Ophiernus vallincola.*

St. 27 ; 37–91 m. *Ophiothrix demessa, Placophiothrix* **phrixa** and *purpurea.*

St. 33 ; 1295 m. **Amphiura ceramis, Anophiura planissima,** *Ophiomusium elegans.*

St. 34 ; 1022 m. *Bathypectinura conspicua, Ophiocrates secunda.*

St. 35 ; 457–549 m. *Ophiernus adspersum.*

* New species in black-face type.

May 2nd–7th, 1934 :

St. 176 ; 655–732 m. *Amphiura grandisquama.*

St. 184 ; 1270 m. *Ophiotreta eximia* and *matura*, *Ophioplinthaca* **papillosa** and *rudis*, *Ophiophthalmus relictus*, **Amphiura ceramis, Homalophiura euryplax.**

St. 185 ; 2000 m. **Amphiura ceramis,** *Ophiura irrorata*, **Ophiozonella brachyactis,** *Ophiotrochus longispinus.*

St. 193 ; 1061–1080 m. **Anophiura plannissima,** *Ophiernus adspersum.*

Of these 31 species, 9 are new and 5 of these were not taken outside the Gulf of Aden ; *Amphiura ceramis* was taken near Zanzibar, *Placophiothrix phrixa* ranges along the South Arabian coast, and *Ophioplinthaca papillosa* extends to the Maldives. Of the remaining 22 species, 8 are East Indian, not known west of the Bay of Bengal, 3 others are East Indian, with their range reaching the Laccadive Islands, another reaches Madagascar, and another South Africa. The occurrence of these species in the Gulf of Aden is interesting evidence that the East Indian fauna tends to reach all parts of the Indian Ocean area. The occurrence of the Japanese *Ophiotrochus longispinus* merely shows that it too belongs to the East Indian fauna. Widespread throughout the Indo-Pacific area is *Ophiothrix demessa*, while *Ophiactis plana*, *Ophiura irrorata* and *Ophiernus adspersum* are virtually world-wide in their distribution in deep water. Approaching this group is *Amphiura grandisquama*, which was first found in the waters of Florida and the West Indies, but is now known from St. Helena (deep water), Natal and the Philippine Islands. Another South African species, *Ophiacantha durbanensis*, now turns up in very moderate depths in the Gulf of Aden. Each of the two remaining species has a notable, and at present inexplicable, range : *Ophiernus vallincola* was first taken in the North Atlantic, later in the Antarctic, and then in the Gulf of Panama, so it is probably more or less nearly cosmopolitan, but its occurrence in the Gulf of Aden is certainly unexpected ; *Ophiocrates secunda* has hitherto been known only from very deep water (2325–2640 m.) off Rio de Oro, West Africa, so its occurrence in water only 1022 m. deep in the Gulf of Aden is hard to understand ; the " Mabahiss " also took it, however, in the Maldive area in 786–1180 m.

South Arabian Coast.

October 27th–29th, 1933 :

St. 42 ; 1415 m. *Ophiacantha pentagona*, *Amphiura uncinata*, *Ophiozonella molesta.*

St. 43 ; 83–100 m. *Placophiothrix aristulata.*

St. 45 ; 38 m. *Ophiacantha pentagona*, *Amphioplus hastatus*, *Ophiactis carnea*, *Ophiothrix otiosa*, **Placophiothrix phrixa,** *Macrophiothrix brevipeda*, *Ophiothela cærulea* (*?* **Ophiochiton megalaspis**), *Ophionereis australis*, *Ophiurodon cupidum.*

October 28th, 1933 :

St. MB II ; 11–29 m. *Amphioplus hastatus*, *Ophiactis carnea*, *Ophiodaphne materna*, *Placophiothrix proteus*, *Ophiothela cærulea*, *Ophiura kinbergi.*

November 2nd–6th, 1933 :

St. 53 ; 13·5 m. *Ophiactis carnea*, *Macrophiothrix brevipeda*, *Ophiothela cærulea.*

St. 54 ; 1046 m. *Ophiacantha abnormis*, *Amphiura diomedeæ*, **eugenioides** and **megalaspis**, *Placophiothrix purpurea*, **Ophiochiton megalaspis, Anophiura simplex.**

St. 59 ; 1948 m. *Ophiura irrorata.*

November 30th, 1933 :

St. 80 ; 16–20 m. *Ophiura kinbergi.*

Of these 23 species, 9 (possibly 10) were taken at St. 45 in shallow water. This is the largest number of species of brittle-stars taken by the " Mabahiss " at any station. It is unlikely that Ophiochiton was taken here, but the others form a very interesting and perhaps typically Arabian group. Of the entire list of 23 species only 5 are new, and 1 (*Placophiothrix phrixa*) of these was taken in the Gulf of Aden also. Of the other 18 species, 12 are East Indian, but several range westward to the Laccadives or to Madagascar or South Africa. One species *Ophiothela cærulea*, is as yet known only from the Arabian coast, while *Ophiothrix otiosa* ranges from the Red Sea to the Malabar coast. One species, *Ophiura irrorata*, is practically cosmopolitan in deep water, while *Amphiura diomedeæ* ranges from South Africa to Panama. The 3 remaining species, *Ophiactis carnea*, *Macrophiothrix brevipeda* and *Ophionereis australis*, were hitherto known only from South Africa, and their occurrence on the South Arabian coast in very shallow water (11–38 m.) is quite extraordinary. Whether they are really absent from the whole East African coast north of Mozambique is, of course, open to question, and further study of the East African littoral fauna is greatly to be desired.

Northern Area of Arabian Sea.

November 18th, 1933 :

St. 62 ; 1893 m. *Ophiacantha vorax*, *Ophiotreta eximia*, *Ophiotoma assimilis*, *Ophiura irrorata*, *Ophiernus vallincola.*

December 6th and 7th, 1933 :

St. 85 ; 1519–1705 m. *Ophiernus vallincola.*

St. 89 ; 135–193 m. **Ophiothamnus longibrachius,** *Amphioplus hastatus.*

Only 1 of these 7 species is new to science and that is based on a unique shallow-water specimen. The other 6 are East Indian, or even more widely spread deep-water forms ; only 1 occurs at depths less than 1200 m.

Gulf of Oman.

November 26th and 27th, 1933 :

St. 71 ; 106 m. *Ophiura kinbergi.*

It is evident that the ophiuran fauna of the Gulf of Oman is scanty, for a single very young individual of this species was the only brittle-star taken in eight hauls of dredge and trawl, not to mention three " grabs ".

Central Area of the Arabian Sea.

April 28th, 1934 :

St. 171 ; 3840–3872 m. *Ophiotypa simplex*, *Ophiopyrgus alcocki*, **Ophiochorus granulatus,** *Amphiophiura convexa*, *Ophiura irrorata*, *Ophiomusium nitidum.*

In some respects this was one of the most interesting hauls made by the " Mabahiss " —only one other was made in deeper water, and that was spoiled by a badly-torn net ; no ophiurans were secured. Of the 6 species taken at St. 171, 2 are new, but 1 of these was also taken at St. 120 in the Zanzibar area, at a depth of 2926 m. Of the remaining 4 species, 3 were also taken at St. 120, and the fourth at St. 119, 1207–1463 m. Koehler's odd species, *Ophiotypa simplex* and *Ophiopyrgus alcocki*, were hitherto known only from the Bay of Bengal, while *Ophiura irrorata* is cosmopolitan in depths exceeding 1000 m. and *Amphiophiura convexa* has an equally wide distribution, but seldom occurs at less than 2500 m. Obviously, therefore, the ophiuran fauna of the central portion of the Arabian Sea is a very typical deep-water fauna, but with possibly half the species confined to the Indian Ocean.

Zanzibar Area.

January 11th–24th, 1934 :

St. 105 ; 238–293 m. *Ophiomyxa bengalensis*, **Amphiura ceramis,** *Amphiura uncinata*, **Anamphiura valida,** *Ophiomusium* **breve,** and *lütkeni*, *Ophiomusa ultima.*

St. 106 ; 183–194 m. **Ophiothrix amphibola,** *Ophiomusium lütkeni*, *Ophiocirce inutilis.*

St. 107 ; 421–457 m. *Ophiomusium validum.*

St. 108 ; 786 m. *Ophioplinthaca rudis*, *Ophiomusium familiare.*

St. 109 ; 640 m. *Ophiomyces delata*, *Amphiophiura paupera*, *Ophiomusium familiare.*

St. 110 ; 347–384 m. *Ophiomusium familiare.*

St. 111 ; 73–165 m. *Ophiocoma insularia* var. *variegata*, *Ophiocirce inutilis.*

St. 113 ; 220 m. *Amphiura atlantica.*

St. 115 ; 640–658 m. *Bathypectinura conspicua*, *Ophiomusium familiare* and *validum.*

St. 118 ; 1789 m. **Ophioplinthaca crassa,** *Amphiophiura trifolium*, *Ophiomusium altum.*

St. 119 ; 1207–1463 m. *Ophioplinthaca rudis*, *Ophiopyrgus alcocki*, *Ophiomastus tumidus*, *Ophiura æqualis* and *irrorata*, *Ophiomusium cancellatum.*

St. 120 ; 2926 m. *Ophiacantha cosmica*, *Ophiolimna antarctica*, *Ophiotypa simplex* **Ophiomastus platydiscus, Ophiochorus granulatus,** *Amphiophiura convexa* and *sculptilis*, *Ophiura irrorata.*

St. 122 ; 732 m. *Bathypectinura conspicua*, *Amphiophiura paupera.*

Of these 32 species, the largest number secured by the " Mabahiss " in any one of the areas under consideration, only 7 represent undescribed species, but 2 others (*Amphiophiura trifolium*, *Ophiomusa ultima*) were only recently (Hertz, 1927) described from off East Africa. Of the other 23 forms, 4 are more or less cosmopolitan in deep water, and another is widespread in the Indo-Pacific region. Of the remainder, 16 are East Indian forms of more or less wide distribution, leaving only 2 species whose range is at all notable. One of these (*Ophiolimna antarctica*) was originally described from the extreme southern Indian Ocean, but was taken by the " Mabahiss " in very deep water in the Maldive area, and hence may be considered as characteristic of the coldest depths throughout the Indian Ocean, even into the Arabian Sea. The other unexpected species, *Amphiura atlantica*,

ranges from St. Helena, south-eastward to South Africa, where it has been taken on the southern coast only as far east as long. 18° 33′ E. The extension of its range on the east coast northward to beyond Zanzibar is therefore surprising, but not at all incomprehensible.

Southern Area of the Arabian Sea.

February 15th and 18th, 1934 :

St. 133 ; 3385 m. **Ophioplinthaca tylota.**

St. 135 ; 2727 m. *Amphiophiura trifolium*, *Ophiura irrorata*, *Homalophiura abyssorum* and **glypta.**

Excepting the cosmopolitan *Ophiura irrorata*, none of these species were taken in the central or northern areas of the Arabian Sea, but *Amphiophiura trifolium* was taken in deep water in the Zanzibar area. Geographically St. 135 is in the Maldive area, but bathymetrically it is obviously to be associated with the Arabian Sea. Hertz (1927) has already recorded *Homalophiura abyssorum* from the vicinity of the Maldives, although it was previously known only from off the West African coast. This strange distribution is like that of *Ophiocrates secunda* and can as yet be explained only by guessing, which is worse than no explanation at all. Whether the apparent difference between the faunas of the southern depths of the Arabian Sea and those to the north and north-west is a real one, or only due to our still very defective knowledge, is also only a guess.

Maldive Area.

March 25th–31st, 1934 :

St. 139 ; 57 m. **Ophiactis spinulifera.**

St. 140 ; 515–525 m. *Astroceras compar*, *Ophiacantha pentagona.*

St. 142B ; 37 m. **Amphiodia minuta.**

St. 143 ; 797 m. **Asteroschema lissum,** *Asteronyx loveni*, *Amphiura diomedeæ* and *nociva*, *Amphiophiura paupera*, *Ophiomusium elegans*, *Ophiopallas palmarum.*

St. 144 ; 31 m. **Ophiactis spinulifera.**

April 2nd–11th, 1934 :

St. 145E ; 494 m. *Ophiomusium elegans.*

St. 153 ; 256–293 m. **Ophiura lanceolata.**

St. 154 ; 457 m. *Placophiothrix aristulata.*

St. 155 ; 2259 m. *Amphiophiura trifolium.*

St. 157 ; 229 m. **Ophiomœris parva, Ophiacantha nudextrema,** *Placophiothrix aristulata.*

St. 158 ; 786–1170 m. **Ophioplinthaca papillosa,** *Amphiophiura paupera*, *Ophiocrates secunda*, *Ophiernus adspersum.*

St. 159 ; 914–1463 m. **Ophioplinthaca papillosa.**

St. 162 ; 1829–2051 m. *Ophiolimna antarctica.*

St. 164 ; 183 m. **Ophiactis hexacantha,** *Placophiothrix purpurea*, *Ophiocoma scolopendrina*, *Ophionereis porrecta.*

Of the 24 species, one-third were hitherto unknown, and 6 of these were taken only in the Maldives ; one other was taken in the Gulf of Aden, and another in the Red Sea. Apparently these novelties do not extend across the deeps of the Arabian Sea to the

African coast. Of the other 16 species 2 were taken by the " Mabahiss " in the Maldive area only, but 1 is well-nigh cosmopolitan in deep water, and the other occurs in the East Indies. There is another nearly cosmopolitan form and 2 species are widespread in the Indo-Pacific region, while 7 others are typical East Indian forms. Of East African species, 2 were taken in the Maldives. There are then only 2 forms whose occurrence in the Maldives is extraordinary—*Ophiocrates secunda*, also taken in the Gulf of Aden, but known hitherto only from deep water off the West African coast, and *Ophiolimna antarctica* from the Antarctic area of the Indian Ocean.

This survey by areas and stations reveals clearly how essentially East Indian the fauna of the Arabian Sea is, for of the 68 previously-known species, 38 are typically East Indian, 5 others range widely throughout the whole Indo-Pacific area, and 7 others are more or less cosmopolitan in deep water. More than 70% of the ophiurans therefore occur in the East Indies. Of the remaining 18 species, 5 are South African (*Ophiacantha durbanensis*, *Amphiura atlantica*, *Ophiactis carnea*, *Macrophiothrix brevipeda*, *Ophionereis australis*), and 4 of these are shallow-water species. Their occurrence as far north as Zanzibar would not be surprising, but 4 of them reach the Arabian coast. Another group of 5 species are as yet known only from the " Mabahiss " collecting grounds ; 2 of these (*Ophiothrix otiosa* and *Ophiothela cærulea*) are shallow-water species of the Arabian and Indian coasts, while the other 3 (*Amphiophiura trifolium*, *Ophiomusa ultima*, *Ophiopallas palmarum*) are deep water forms from the East African coast, *Ophiopallas* and *Ophiomusa* extending their range to the Maldives. Still another group of 3 species (*Ophiolimna antarctica*, *Amphiophiura scupltilis*, *Ophiernus vallincola*) are denizens of the Antarctic seas, though the last two occur also in very deep, cold water in the Pacific, and are probably more or less cosmopolitan in cold water deeps. The extension of their range into the Arabian Sea is therefore not surprising. The occurrence of the 5 remaining species, in the " Mabahiss " collections is sufficiently unexpected to warrant a word about each. The " Challenger " found *Ophiacantha cosmica* throughout the southern hemisphere, and it has since been found in the Panamic region and in the North Atlantic ; it may fairly be listed with the cosmopolitan deep-water species just mentioned. The case of *Amphiura grandisquama* is more difficult to understand. It was first taken in the West Indian region in moderately deep water, and subsequently in the Philippines (Koehler, 1922, p. 159) in relatively shallow water. Then Mortensen (1933*a* and *b*) reported it from near St. Helena, and from off the coast of Natal. Now the " Mabahiss " finds it in the Gulf of Aden in moderately deep water. Such distribution is at present inexplicable. Mortensen (1933*b*, p. 354) says that it " might indicate " that the range " from the West Indies to the Philippine Seas is not now continuous ", but even if that is granted, it is still a problem how it ever could have been continuous across the abyssal deeps of the Atlantic and Indian Oceans, since *grandisquama* has never yet been taken at a depth of over 1200 m. In *Ophiomusium validum* we have a somewhat similar puzzle. Discovered in the West Indies in 390–450 fms. by the " Challenger ", this brittle-star has since been taken by both the " Investigator " and the " Siboga " in Indian and East Indian Seas at similar or somewhat greater depths, and now by the " Mabahiss " off Zanzibar. In *Homalophiura abyssorum* and *Ophiocrates secunda*, we have 2 additional species which were originally found in the Atlantic and now are known from the Gulf of Aden and the Maldives, but not from anywhere else. Both, however, are species of very deep cold water, and the possibility of a more or less continuous cosmopolitan distribution cannot be ignored.

Turning now to the bathymetrical distribution of the 102 species taken by the "Mabahiss", we find that disregarding 4 species from unknown stations, 29 species are littoral, occurring in less than 100 m., and 20 species are abyssal, occurring in depths greater than 2000 m. Exactly half the species therefore are from the continental slope. But if we consider this group more carefully we find more than half of them are really deep-water forms, occurring with but few exceptions only in depths of more than 1000 metres. The littoral species are chiefly in the families Amphiuridæ, 10 species, of which 6 are Ophiactis, and Ophiotrichidæ, 10 species, of which 5 are Placophiothrix.

As the result therefore of this study of the "Mabahiss" collections we may say that the ophiuran fauna of the Arabian Sea and the adjoining coasts has undoubtedly originated in the East Indian region, but has not yet developed nearly so rich a littoral group. There has been a considerable influx of cosmopolitan deep-water species and some Antarctic forms from the south, and with this apparently 2 or 3 Atlantic species have arrived, but this group has not materially affected the East Indian aspect of the fauna. Its most remarkable feature, emphasized by the "Mabahiss" collections, is the large proportion of endemic species which have been developed in this relatively small area. Only one-fourth of these occur in the Maldive area (that is nearest to the East Indian region), and only 2 or 3 are abyssal forms. The southern Arabian coast, the Gulf of Aden and the East African area near Zanzibar have provided the conditions which have apparently favoured speciation. Of the new genera, 4 are from the Gulf of Aden and one from Zanzibar; the locality whence came the specimen upon which Amphiomya is based is unfortunately unknown.

In conclusion I wish to offer my sincere thanks to Lt.-Col. R. B. Seymour Sewell and the authorities of the British Museum for the privilege of studying this unusually interesting collection. While a large proportion of the specimens are in very poor condition, with most of the arms broken and the disks often crushed or missing, the labelling and packing is the best of any large collection I have studied. The poor condition is obviously due to the difficulties under which the dredging and trawling were done, but the excellence of the sorting and labelling bears witness to the care and thoroughness of the Director of the Expedition and the patience of all the workers. For the illustrations, Mr. Eugene N. Fischer is to be heartily thanked; his patience and care are beyond praise.

ANNOTATED LIST OF SPECIES.

Order **PHRYNOPHIURIDA.**

Family **OPHIOMYXIDÆ.**

Ophiomyxa australis Lütken.

Ophiomyxa australis Lütken, 1869, pp. 45 and 99. H. L. Clark, 1915, p. 168; pl. 1, figs. 1 and 2.
Ophiomyxa brevispina von Martens, 1870, p. 249.

Locality.—No label or clue. One specimen.

Range*.—Mauritius to Fiji; Japan to South Australia, in shallow water (littoral).

Notes.—This single specimen, labelled only "Op 11", is 11 mm. across the disk,

* The given range is that known up to the date of the "Mabahiss" explorations. The extensions of range which her discoveries have made are thus more clearly emphasized.

but the arms are scarcely 30 mm. long. The skin of disk and arms, both above and below, is notably thick, completely concealing the plates and scales even in the dry condition, except in the interradial areas, where marginal plates are clearly in evidence. The arms are notably slender and the arm-spines short, flattened and blunt. The colour (dry) is a dingy, yellowish-white.

Remarks.—Study of this specimen and comparison with a good series of Ophiomyxas from Australia, Japan, Mauritius, Fiji and the Caroline Islands, has convinced me that *brevispina* must be considered a synonym of *australis*. The present small specimen is far from typical.

Ophiomyxa bengalensis Koehler.

Ophiomyxa bengalensis Koehler, 1897, p. 363, pl. 9, figs. 70, 71 ; 1922, p. 17, pl. 5, figs. 5, 6.

Locality.—Station 105 ; Zanzibar area ; 310 metres. Two specimens.

Range.—China Sea to the Kei Islands, westward to the Andaman Islands and the coast of Natal, 250–550 metres.

Notes.—The larger of the specimens is 20 mm. across the disk, with arms 125 mm. long. The smaller one is somewhat more than half as large. The colour, whatever it may have been, has entirely disappeared, leaving only the usual dingy light yellowish of alcoholic specimens.

Remarks.—The numerous minute plates in the skin of disk and on the upper side of the arms are plainly visible in the dry condition, and, with the slender, acute arm-spines make the recognition of the species easy. The absence of plates at the periphery of the disk is also an important character.

Family **TRICHASTERIDÆ.**

Asteroschema lissum* sp. nov. (Text-figs. 1–3.)

Locality.—Station 143 ; Maldive area ; 797 metres. One specimen.

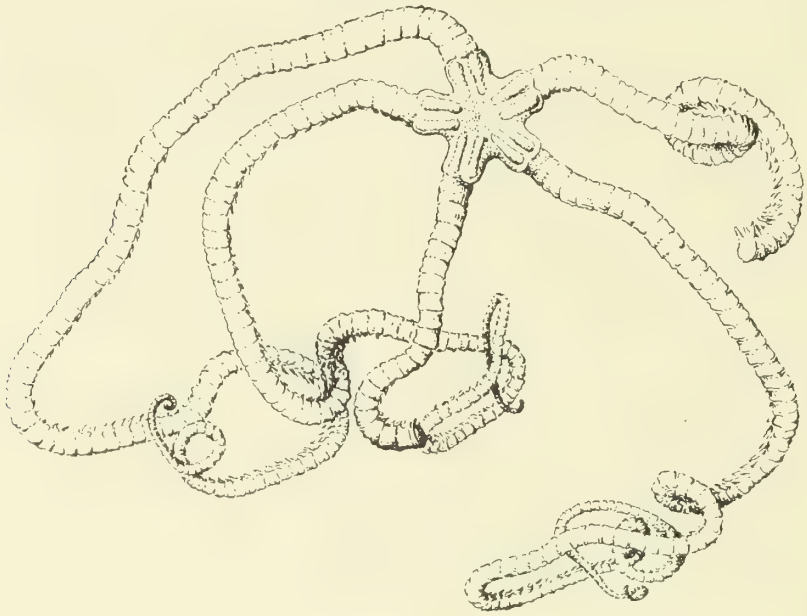
Description.—Disk 7·5 mm. in diameter ; arms 5, about 110 mm. long, tapering distally to a very slender tip, more than twelve times the disk-diameter. Disk flat or slightly concave at centre, pentagonal but with the interradial sides deeply concave or notched. Radial shields narrow, straight and parallel, separated from each other by a shallow depression nearly as wide as the distal end of each shield. Surface of disk, including the radial shields, covered closely with very fine low granules, about 40–60 to a square millimetre near margin, but noticeably smaller at centre of disk and on proximal part of radial shields. Upper surface of arms strongly convex and covered with a granular coat like that of the disk ; sides of arms more or less vertical with granular coat more sparse, but continuous to base of arm-spines ; beyond the middle of the arms the granular coat becomes more and more sparse and distally the skin covering the arms is quite smooth and naked.

Interbrachial areas nearly 3 mm. high, the space between the long, obliquely placed genital slits, deeply depressed ; granular coating evident but sparser than on disk ; oral surface of disk and arms covered with naked, thin skin. First arm-pore without a

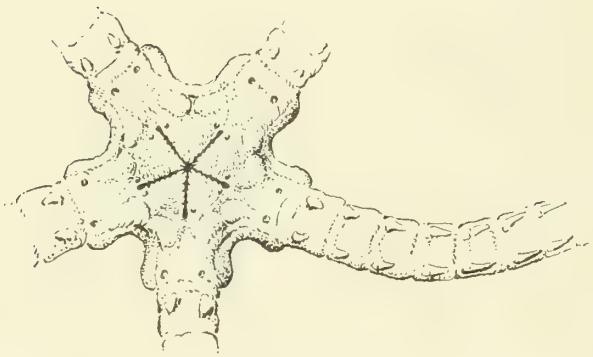
* λισσός = smooth.

protecting arm-spine. The following 8–10, with a single spinelet, shorter than, or finally equalling, the joint; succeeding pores with 2 spinelets, of which the outer is shorter than, or barely equals, the joint and is smooth, while the inner becomes two or three times as long, thickened and prickly at tip. Oral papillæ 3–5 on each side of the mouth slit, but very slightly differentiated, and in no case well defined. Teeth better defined, but

TEXT-FIG. 1.



TEXT-FIG. 2.



TEXT-FIG. 3.

TEXT-FIGS. 1–3.—*Asteroschema lissum* sp. nov. FIG. 1.—Entire specimen from dorsal side. × 2. FIG. 2.—Oral surface of disk and arm-bases. × 4. FIG. 3.—Oral surface of part of arm, distally. × 4.

not very large, more or less triangular and pointed at tip. Colour (dry) reddish white, lightest on the radial shields, darkest on the jaw tips and on the distal part of the arm-spinelets.

REMARKS.—This is a poorly characterized species in an ill-defined genus. I have sought in vain to refer it to some known species. It is quite unlike the Indian Ocean species, *rousseaui*, to which I at first referred it, if de Loriol's careful description of that form is not to be ignored. It is even more unlike *flosculum* Alcock, another Indian form. It seems to be nearest to the Japanese species *hemigymnum* Matsumoto, but the body

form, radial shields and much less crowded granular coat prevent thus referring it. I therefore regretfully add another species to a genus, of which our knowledge is still very unsatisfactory.

Astroceras compar Koehler.

Astroceras compar Koehler, 1904, p. 158 ; pl. 22, fig. 5 ; pl. 30, fig. 9 ; pl. 32, fig. 3.

Locality.—Station 140 ; Maldive area ; 550 metres. One specimen.

Range.—Philippines and East Indies from Luzon to the Kei Islands. 204–385 metres.

Notes.—This specimen has the disk about 17 mm. across and the arms, which are more or less intertwined and hence hard to measure, are about 125 mm. in length. The colour ranges from light brown to nearly white in the dried condition. There is no clue as to what it may have been in life. The tubercles on the radial shields are numerous (8–12) and not very large (·30–·80 mm. in diameter), nearly spherical and minutely rough. Those on the basal arm-joints are very similar ; there are often 3 on each side of a segment, one being larger than the other two. The arm-spines and mouth-parts show no features worthy of note.

Remarks.—The proportions of this individual are very near those of Koehler's original material, the arms being about eight times the disk diameter, whereas Döderlein (1927, p. 80) says that the arms are " 10–11 " times the disk diameter. This difference is probably due to the differences in the condition of the specimens measured, and to the difficulty of measuring the arms in preserved specimens with any accuracy. The occurrence of *compar* in the Maldive area is interesting, as the geographical range is thus extended far to the west.

Asteronyx loveni Müller and Troschel.

Asteronyx loveni Müller and Troschel, 1842, p. 119 ; pl. 10, fig. 3–5.

Locality.—Station 143 ; Maldive area ; 797 metres. One specimen.

Range.—Well-nigh cosmopolitan, in 150–2500 metres.

Notes.—As this species usually occurs in considerable numbers, where it is found at all, it is curious that only a single specimen occurs in the present collection. This one is still quite young, but 11 mm. across the disk, with the arms not over 100 mm. long.

Remarks.—Although Koehler (1904, p. 74) lists this species as being taken by the " Investigator " in the deep waters of the Indian Ocean, he gives neither a locality nor the depth. It is probable that the present record extends the known range considerably to the north-west.

Order **LÆMOPHIURIDA.**

Family **HEMIEURYALIDÆ.**

Ophiomœris parva* sp. nov. (Text-figs. 4 and 5.)

Locality.—Station 157 ; Maldive area ; 229 metres. Ten specimens.

Description.—Disk, 3 mm. in diameter ; arms 5, each about 9 mm. long, relatively stout at base, but tapering to a slender tip. Disk flat, conspicuously 5-lobed, each lobe

* *parvus* = small.

covered for the most part by a pair of radial shields, whose rounded distal angles, separated by a triangular plate with a straight outer margin, cause the lobe to appear abruptly truncate over the base of each arm ; a conspicuous circular central plate, 4 or 5 low and wide, more triangular plates in each radius, and 3–5 small or very minute plates in each interradius, cover the rest of the upper surface of the disk. Radial shields relatively large, nearly a millimetre long and almost half a millimetre wide, apple-seed-shaped, with the wider end distal, nearly in contact at middle, but well separated at the ends. Upper arm-plates small but very distinct, rounded triangular ; the basal ones are twice as wide as long, but they soon become more nearly equilateral.

Interbrachial areas below very small, covered by two or three minute plates between the large and nearly vertical genital scales ; genital slits small, but relatively conspicuous. First under arm-plate relatively big, longer than wide, noticeably wider proximally than distally ; succeeding plates much wider than long, rounded diamond-shaped, becoming very small distally. Side arm-plates large, not conspicuously projecting even at the more evident distal margins, meeting broadly on both the upper and lower surface of the

Text-fig. 4.

Text-fig. 5.

Text-figs. 4, 5.—*Ophiomœris parva* sp. nov. Fig. 4.—Dorsal view of disk. × 10. Fig. 5.—Side view of 3 basal arm-segments. × 15.

arm. Each plate carries 6 (or 5) opaque, bluntly-pointed arm-spines, which are not at all thorny, but are not perfectly smooth ; the series on the first arm-segment (distal to disk) meet more or less completely in the midline above, and the uppermost spine of each series is much elongated, equalling the first 3 arm-segments ; the second spine is much shorter, but is relatively long, while the following spines are successively shorter, the lowest being much shorter than the segment. On the following segments the uppermost spine is not so disproportionately big, hardly as long as the segment. Tentacle-scale small, thick and pointed. Oral shields diamond-shaped, wider than long, rather large and slightly swollen ; adoral plates very large, broadly in contact in front of oral shield, but separated radially by the first under arm-plate. Oral papillæ 3 on each side of each jaw, the outermost widest, the innermost narrowest and most pointed. Colour of dried specimens greyish white, darkest on disk, lightest on oral surface of arms distally.

Remarks.—Although there can be little doubt that this ophiuran is an Ophiomœris, it is easily distinguished from the other members of the genus by the strikingly different arm-spines. The absence of granules on the disk is also noticeable and there are other

differences in the oral shields and under arm-plates. It is hard to see why Koehler, who established the genus Ophiomœris and described and figured its type species, *spinosa*, should have published such an inaccurate and misleading figure of the dorsal surface of his new species (1904, pl. 4, fig. 1), or why he should have described the dorsal surface as covered by " plaques nombreuses, inegales, arrondies ". There are now in the Museum of Comparative Zoölogy two of Koehler's specimens, co-types, and the dorsal surface is covered chiefly by the radial shields with relatively few, rather thick and often angular or irregular plates. The figure given is even more misleading for the radial shields of the co-types are nearly in contact radially at the middle, and each pair covers a radial " lobe ", comprising one-fifth of the disk. Misled by Koehler's figure, I (1911, p. 250) considered that Lyman's *Ophioceramis obstricta* (1882, p. 26, pl. 11, figs. 1–3) could not be congeneric with *spinosa*, and I therefore established a new genus Ophiurases for it. Matsumoto, however, (1917, p. 139) detected my blunder and assigned my new name to the synonymy of Koehler's genus—a course subsequently endorsed by Koehler himself.

Ophiomœris therefore is apparently a genus of six species, *spinosa* Koehler, *obstricta* Lyman, *clausa* Lyman, *projecta* Matsumoto, *tenera* Koehler, and the here-described *parva*. Lyman's *clausa* is, however, quite different from the others and had best be made the type of a new genus, for which I suggest the name Ophiocyclus.* It resembles Ophiomœris in the general character of the oral frame and in the small upper and under arm-plates, but the disk is flat, perfectly circular with no radial " lobes " so marked in Ophiomœris, and large interbrachial areas below with a single plate covering nearly all of each. The very slender upper arm-spines are also quite different from those of Ophiomœris. Lyman's description and figures (1882, p. 26, pl. 11, figs. 4–6) are admirable, as re-examination of one of his types shows.

The ten specimens of *Ophiomœris parva* in the present collection are very much alike, having the disk 2–3 mm. across, and the colour more or less nearly white, in rather evident contrast to the fragments of a pale grey sponge to which four of them still cling very closely. It is obvious that all of them were taken from a branching sponge (one or more), upon the more slender branches of which they were living. For such a life they are structurally well adapted.

Family **OPHIACANTHIDÆ.**

Ophiacantha abnormis Lyman.

Ophiacantha abnormis Lyman, 1879, p. 59 ; pl. 15, fig. 411–413.
Ophiacantha gratiosa Koehler, 1897, p. 346 ; pl. 8, figs. 60, 6_.

Locality.—Station 54 ; South Arabian coast ; 1046 metres. Fifteen specimens.

Range.—Philippine Islands westward to Laccadive Islands, 347–1260 metres.

Notes.—These specimens are for the most part in such poor condition, they add but little to our knowledge of the species. They range in size from 9 to 16 mm. across the disk, and the arms when most nearly complete are about three times the disk diameter, but the attenuate terminal portion is constantly lacking. The colour (dry) is a quite indistinctive light grey or greyish white. The label gives the depth at which they were taken as 952 metres, but in the station list Station 54 is recorded as having a depth of 1046 metres.

* Ophio + κύκλος = a circle, in reference to the very definitely circular disk.

The inconsistency is not important, however, as the " Challenger " took the original specimens at 675–1260 metres.

Remarks.—Koehler (1897) decided that the Ophiacanthas collected by the " Investigator " which resembled *abnormis* were not identical with the " Challenger " species, and hence he described them under the name *gratiosa*. Comparison of some of his type material with that of Lyman shows, however, that he was misled by Lyman's poor figures and by his own unwillingness to allow for individual diversity. There is no doubt that *abnormis* and *gratiosa* are identical. The species *inutilis*, taken by the " Siboga " is very similar, but comparison of one of Koehler's types with the other material at hand seems to justify keeping them apart, at least until larger series of specimens are available.

Ophiacantha ameleta H. L. Clark.

Ophiacantha ameleta H. L. Clark, 1938, p. 209.
Ophiacantha dallasii Döderlein, 1896, p. 291 ; pl. 14, figs. 3*a–c* ; pl. 16, figs. 12, 12*a*.

Locality.—Unknown. No label with the single specimen but " Op. 11 ".

Range.—Northern Australia, East Indies and Philippines, in shallow water (littoral).

Note.—The disk is about 2 mm. across, and the arms are all broken, but three have only the terminal part missing. The colour (dry) is nearly white. The large spines on the second arm-segment are conspicuous, so that the identification is reasonably sure.

Remarks.—As was pointed out in my Australian Report (1938) Döderlein and Koehler confused this small tropical Ophiacanthid with a Korean species named by Duncan in 1879, which has very different arm-spines. It is regrettable that there is no clue as to the locality where the present specimen was taken, for its occurrence in the north-western Indian Ocean is a notable extension of its range.

Ophiacantha cosmica Lyman.

Ophiacantha cosmica Lyman, 1878, p. 146 ; pl. 10, figs. 251–254.
Ophiacantha aculeata Verrill, 1885, p. 547. Koehler, 1914, p. 74 ; pl. 11, figs. 1, 2.

Locality.—Station 120 ; Zanzibar area ; 2926 metres. One specimen.

Range.—Widespread in very deep water (590–4018 metres) in the southern hemisphere, in the Panamic region, and in the North Atlantic.

Notes.—This specimen is a large one, about 16 mm. across the disk, but it is in very poor condition, owing apparently to the rough handling in the trawl. The arms are all broken, only one exceeding 50 mm. in length. The arm-spines and upper arm-plates are more or less broken, very few showing the normal appearance, and the disk spinelets are mostly rubbed off. The colour (dry) is nearly white, but has a yellowish tinge.

Remarks.—This Ophiacanthid has not been previously reported in the Indian Ocean, but there is good reason for believing that it is nearly cosmopolitan in the abyssal region. A specimen in the Museum of Comparative Zoology, taken in the North Atlantic, south of Marthas Vineyard in 1394 fathoms (" Blake " Station 340 ; 1880), carries a note in Lyman's handwriting—" 5–7 smooth spines while *millespina* has 7–8. Upper arm-plates also different. *O. cosmica* ? " But Mr. Lyman never published anything about this specimen, which is first listed in my ' Catalogue of Recent Ophiurans ' (1915, p. 197), under the name *Ophiacantha cosmica*, comparison with specimens of *cosmica* of similar size

(10–12 mm. across the disk) from off the coast of Peru in 2222–2338 fms., showing that there is no adequate reason for calling them by different names. In 1885, however, Verrill had named the Atlantic form *aculeata*, and in 1914 Koehler published two excellent photographs of one of Verrill's original specimens. Neither Verrill nor Koehler make any reference to *cosmica*, apparently assuming, quite naturally, that a southern Pacific species would not occur in the Northern Atlantic. This conclusion has been generally accepted by later writers, but apparently it is incorrect, and *cosmica* must be recognized as a more or less cosmopolitan, abyssal Ophiacantha.

Ophiacantha durbanensis Mortensen.

Ophiacantha (*Ophiotreta*) *durbanensis* Mortensen, 1933*a*, p. 324, figs. 44*a*, *b* ; pl. 19, figs. 13–15.

Locality.—Station 24 ; Gulf of Aden ; 73–200 metres. One specimen.

Range.—Natal, off Durban, 225 fms. (405 metres).

Notes.—This specimen is a very young Ophiacanthid only 3·5 mm. across the disk. The arms are all broken, but in life could hardly have exceeded 15 mm. The disk is covered sparsely with rough, pointed granules, a very few of which are sufficiently elongated to be called spiniform. Excepting the basal 3 or 4, the under arm-plates are longer than wide, and have a nearly straight distal margin. The oral shields are wider than long and there are 6 or 7 oral papillæ on each side of each jaw. The colour (dry) is pale brownish yellow or dirty white.

Remarks.—In spite of the differences just mentioned it seems better to refer this little Ophiacantha to Mortensen's South African species, which it resembles in the upper arm-plates, spines, oral armature and tentacle-scales, than to identify it with the Japanese species *bisquamata* Matsumoto. It would not be justifiable to base a " new species " on so young and imperfect a specimen.

Ophiacantha pentagona Koehler.

Ophaicantha pentagona Koehler, 1897, p. 342 ; pl. 8, figs. 56 and 57.

Localities :

Station 24 ; Gulf of Aden ; 73–200 metres. Five specimens.
Station 25 ; Gulf of Aden ; 620 metres. One specimen.
Station 42 ; South Arabian Coast ; 1415 metres. Two specimens.
Station 45 ; South Arabian Coast ; 38 metres. Three specimens.
Station 140 ; Maldive area ; 515–525 metres. Seven specimens.

Range.—Sagami Bay, Japan, southward to the Kei Islands and westward to the Andaman Islands, 81–1698 metres.

Notes.—These specimens are, with few exceptions, in very poor condition and are mostly immature. Their identification is therefore in many cases open to question, but only in the case of the two specimens from Station 42 do I feel any serious doubt. These individuals are scarcely 5 mm. across the disk, and the seemingly short arms are much twisted, curled inwards and broken. The disk covering is made up of lower, coarser and fewer spinelets than usual, there are as a rule, 4 oral papillæ on each side of each jaw, and the colour (dry) is light yellowish or nearly white.

Ophiacantha vorax Koehler.

Ophiacantha vorax Koehler, 1897, p. 353 ; pl. 8, figs. 68 and 69.

Localities :

Station 26 ; Gulf of Aden ; 2312 metres. Eight specimens.

Station 62 ; Northern Area of Arabian Sea ; 1893 metres. One specimen.

Range.—Celebes and Kei Islands to Cape Comorin, India, 1788–2029 metres.

Notes.—In spite of the rather poor condition of these specimens, there is no apparent reason for doubting that they belong to the same species as the " Investigator " Ophiacantha to which Koehler gave the name *vorax*. They range from 5 to 8 mm. across the disk, and the arms are about six times that. But as the arms are quite attenuate and the terminal part is usually lacking, it is probable that they are in life fully eight times the disk diameter, as Koehler says in his original description. The colour of the specimens (dry) at hand is dirty whitish or very pale grey brown.

Remarks.—Koehler (1922) discussed the relationship of this species to some of its near allies, but material is still inadequate for a final decision on the questions of synonymy in the group.

Ophiacantha nudextrema* sp. nov. (Text-fig. 6.)

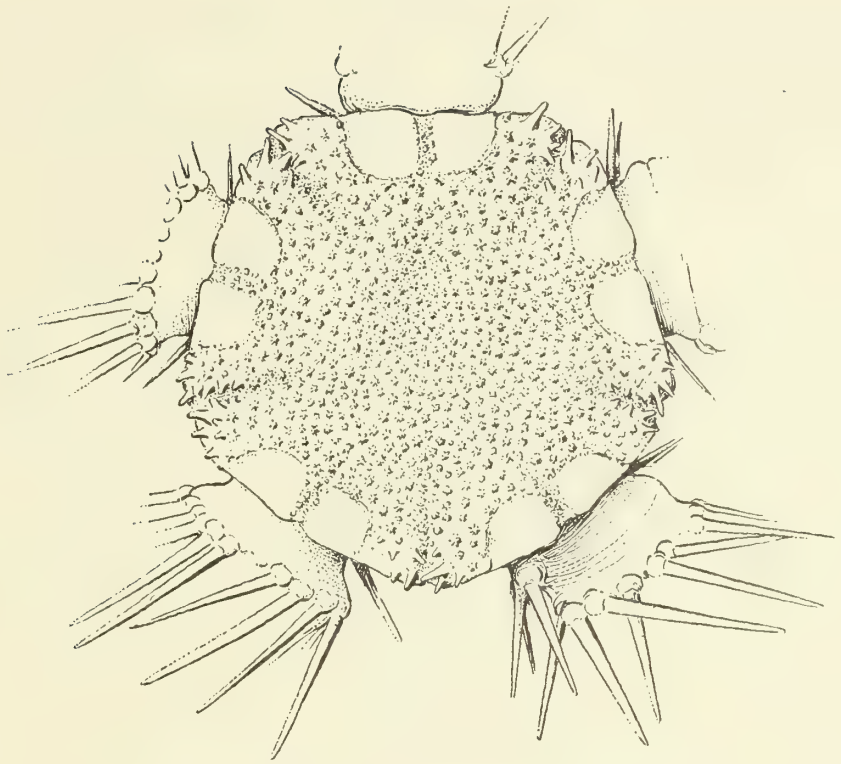
Locality.—Station 157, Maldive area ; 229 metres Six specimens.

Description.—Disk 3 mm. in diameter ; arms 5, each about 14 mm. long, slender, tapering, more or less moniliform, and curled inward or twisted. Disk nearly circular, but more or less decagonal, flat or slightly concave, covered (but not densely) with low, rather thick " stumps ", which are truncate and thorny at tip ; very commonly the tip is trifid, and each of the three branches ends in several low teeth. On the interradial corner of each radial shield the stumps tend to become distinct blunt spinelets without thorns. Radial shields elongated triangular, for the most part concealed, as are the disk-scales, by the thorny stumps, but the distal ends, excepting the interradial corners, are conspicuous, thick, bare, and concave at the margin. Upper arm-plates small, triangular, somewhat convex, widely separated from each other by the big side arm-plates, their distal margin nearly straight or a little convex ; the length scarcely exceeds the breadth.

Interbrachial areas below small, bare, with very large genital slits and a few short thick stumps close to the disk margin. First under arm-plate nearly square, with somewhat rounded corners ; second plate broadly triangular, much wider than long ; succeeding plates well separated by the side arm-plates, more or less pentagonal or increasingly bell-shaped, as long as wide or longer. Side arm-plates very large and conspicuous, meeting broadly both below and above, and projecting enough to make the arms moniliform ; they each carry 8 spines on the first segment distal to disk, the uppermost longest and equal to at least two segments ; the two series on this first segment are closely approximated dorsally ; on succeeding segments the rows do not so nearly meet, the number of spines dropping to 6 and then to 5. Spines slender, terete, nearly or quite smooth (rough or thorny when magnified 90×), but the lower ones may be slightly thorny, even under little magnification. Tentacle scale single, rather large, wide and pointed.

Oral shields much wider than long, diamond-shaped with rounded angles ; madreporite more nearly pentagonal and about as long as wide. Adoral plates short, wide and

* *nudus* = naked + *extrema* = tips, in reference to the bare tips of the radial shields.



TEXT-FIG. 6.—*Ophiacantha nudextrema* sp. nov. Dorsal view of disk. × 20.

thick, their outlines rather indistinct; they seem to meet more or less fully proximal to the oral shield. Oral papillæ 3 (rarely 4) on each side of each jaw, thick and pointed. They are minutely rugose like the lowest tooth, which they resemble, though it is distinctly larger. Colour of dried specimens nearly white, but with more or less of a pearl-grey tinge.

REMARKS.—Although all of the specimens are in poor condition, there seems no reason why they should not be referred to Ophiacantha, but I find no species in that genus to whose description they answer. Apparently related to *pentagona*, they are readily distinguished by the character of the disk, a feature that separates them also from other species of the same small size and general character.

OPHIOTHAMNUS LONGIBRACHIUS* sp. nov. (Text-fig. 7.)

LOCALITY.—Station 54; South Arabian coast; 1046 metres. One specimen.

DESCRIPTION.—Disk missing, but the scar on the arm bases shows that it was little more than 2 mm. across; the scaling and the character of the radial shields are, of course, unknown. Arms 5, each about 40 mm. long, very slender and strongly moniliform. Upper arm-plates small and widely separated, convex, triangular, much wider than long; basally and even distally the width seems to exceed the length.

Interbrachial areas missing. Under arm-plates of moderate size, longer than wide, widest distally and more or less bell-shaped, well separated. Side arm-plates large and projecting, meeting above and below. Arm-spines slender, terete, translucent and nearly

* *longus* = long + *brachium* = arm, in reference to the extremely long arms.

or quite smooth ; on the basal joints there are 7 or 8 on each side and the series are closely approximated in the mid-dorsal line; the uppermost spines are fully equal to three arm segments ; the lowest scarcely exceed one. Distal to the fifth or sixth segment, the uppermost spines are shorter and the series are no longer closely approximated, but the change, though well-marked, is not abrupt. Tentacle-scale single, slender and acute. Oral shields small, very long and narrow, sharply pointed at the inner end, but more rounded distally ; the width is scarcely half the length. Madreporite somewhat swollen distally. Adoral plates relatively large ; each one is larger than the oral shield ; inner ends narrow and more or less evidently in contact ; outer ends wider and truncate. Oral papillæ 3 on each side, the outermost very low and wide, nearly equalling the adoral plate which it adjoins; the middle papilla is flat and truncate, and the innermost, a little narrower, may be more or less pointed, but is relatively wide and blunt. Teeth very large, flattened and wide at tip, which is usually more or less notched, and may show a central point or two. Colour (dry) white.

Remarks.—In spite of its defective condition there is no room for doubt of the generic position of this brittle-star, for its relationship to the genotype, *O. vicarius* Lym., is beyond

Text-fig. 7.—*Ophiothamnus longibrachius* sp. nov. Lower surface of oral frame. × 25.

question. A number of small Ophiacanthids in which the disk and general appearances suggest Ophiothamnus have been referred to the genus, but their mouth parts are so unlike those of *vicarius*, they should not be retained in the genus. This Maldive Island specimen has the characteristic features of the mouth-parts well marked, but at the same time the very long and slender arms and extraordinarily narrow oral shields distinguish it at once from any of the previously known species, so that I have no hesitation in giving it a name. Obviously it is a pity, however, that so interesting a species of a genus not hitherto known from the Indian Ocean, should be based on a single defective individual.

Ophioplinthaca rudis (Koehler).

Ophiomitra rudis Koehler, 1897, p. 358 ; pl. 9, figs. 74, 75.*
Ophiomitra cardiomorpha H. L. Clark, 1911, p. 179, fig. 81.
Ophioplinthaca rudis Koehler, 1904, p. 132.
Ophioplinthaca cardiomorpha H. L. Clark, 1915, p. 210.

Localities:

Station 108 ; Zanzibar area ; 786 metres. One specimen.
Station 119 ; Zanzibar area ; 1207–1463 metres. Three specimens.
Station 184 ; Gulf of Aden ; 1270 metres. One specimen.

**Not* figs. 75 and 76 as given on p. 358.

Range.—Omai Saki, Japan, southward to Timor, and westward to the Maldive and Laccadive Islands, 650–1316 metres.

Notes.—These five specimens range from 10 to 14 mm. in disk diameter and show but little diversity. The specimen from the Gulf of Aden has more slender spinelets on the disk and the upper arm-spines seem unusually long and slender ; in this individual the arms are nearly complete and almost straight, and measure fully 60 mm. in length. The other specimens are coarser and the arms are distinctly stouter and more or less incurved towards the mouth, but only in the smallest specimen are they almost complete. The colour of all (dry) is nearly white.

Remarks.—The unfortunate typographical error by which " figs. 75 et 76 " are said to represent *rudis*, in connection with the original description, misled me when I was preparing my report on North Pacific ophiurans (1911), and the figures published later (1899, pl. vii, figs. 58, 59) are still too diagrammatic to make the species recognizable. As a consequence, the Japanese specimens were described as a new species under the name *cardiomorpha*. When, however, Koehler published his admirable photographic figures of *rudis* (1922, pl. 24, figs. 1–6), the identity of the Japanese species with his was established, and comparison of a " Siboga " specimen with a co-type from Japan leaves no room for doubt. It is a little surprising that Koehler did not himself detect this identity, for in his "Albatross " report (1922) he has been critical of a number of other Japanese forms which I considered " new ", and his views are in general well-founded. The extension of the range of *rudis* to Zanzibar and the Gulf of Aden is very interesting.

Ophioplinthaca crassa* sp. nov. (Text-figs. 8 and 9.)

Locality.—Station 118 ; Zanzibar area ; 1789 metres. One specimen.

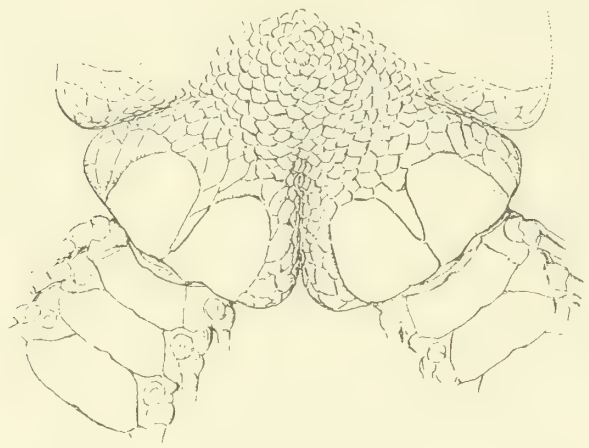
Description.—Disk 14 mm. in diameter, nearly flat, but a little concave near centre ; radial wedges well marked, elevated but little above arm-bases, covered chiefly by their flat radial shields and half a dozen overlapping, coarse disk-scales on the interradial margin of each ; proximal portion of each wedge covered, like the centre of disk, by numerous, irregularly rounded scales ; on a single one of these scales is a low, cylindrical tubercle of small size, but otherwise the disk bears no projections ; radial shields about 2·5 mm. long by 2 mm. wide, either slightly separated by a long narrow scale distally, or more or less in contact there. Arms 5, all broken, but noticeably stout, 4 mm. wide (without spines) and 3 mm. high basally ; apparently about 70 mm. long in life. Upper arm-plates as usual in typical species of the genus, much wider than long, widest at distal margin, which is slightly convex ; lateral margins curve inwards at first slowly, then abruptly to the mid-line, where they meet in a more or less evident point ; first two plates in contact rather broadly, but subsequent plates separated by the side arm-plates meeting in mid-dorsal line.

Interbrachial areas below moderately large, not markedly contracted at oral shield, covered with rather numerous scales ; occasionally one of these scales bear a short, smooth, club-shaped spinelet ; genital slits not noticeably widened. First two under arm-plates much wider than long, with slight anterior and posterior projections and long narrow lateral wings ; they are in contact at the thickened anterior and flat posterior median projections, but otherwise are well separated from each other ; the following plates are

* *crassus* = coarse, in reference to its broad, stout arms.

more broadly in contact and are somewhat wider, especially on the distal side ; from the sixth plate on, they become nearly as wide proximally as distally, and are more or less quadrangular, but the distal margin is convex, more or less thickened near middle and often has a distinct notch there. Side arm-plates stout and projecting laterally ; they meet very narrowly above and below except at the base of the arm, where they are quite separated on the first two or three segments ; at the middle of the arm each carries a series of 4 short, stout, but fragile, thorny arm-spines, the lowest is shortest and equals two segments, but the uppermost is not much longer ; on the basal segments there is a fifth spine, and on the first two or three a sixth and even a seventh is present ; owing to the poor condition of the specimen it is impossible to determine the form and relative length of the uppermost spines. Tentacle-scales more than a millimetre long, nearly a

TEXT-FIG. 8.



TEXT-FIG. 9.

TEXT-FIGS. 8, 9.—*Ophioplinthaca crassa* sp. nov. FIG. 8.—Dorsal view of half of disk. × 5. FIG. 9.—Oral view of same. × 5.

millimetre wide basally, very thick, somewhat triangular, bluntly pointed on the first two or three segments ; on succeeding segments, they are less stout and have slender points but they decrease little in length. Oral shields definitely pentagonal, with rounded angles and thickened margins, about as long as wide ; distal lateral margins concave ; madreporite not noticeably bigger than the others. Adoral plates short and wide, meeting broadly within. Oral papillæ crowded, 5 on each side, the distal ones low and wide, the proximal 3 narrower and more pointed. Teeth long, stout and pointed. Colour of dry specimen nearly white.

REMARKS.—The poor condition of this specimen is apparently due to the rough journey in the dredge from the great depth at which it was taken. All the arm-spines excepting some of the lowest are broken or have been pulled off, as a result of which the actual appearance of the arms in life cannot be pictured, but not even the basal series were at all nearly approximated dorsally. The species is well set apart from its near relatives by the broad, rounded radial shields, the absence of tubercles or thorny stumps or spinelets on the disk, the definitely pentagonal oral shields and the very stout tentacle scales. The stout thickened arms are also a good character when it is compared with any of the other Ophioplinthacas taken by the " Mabahiss ".

Ophioplinthaca papillosa* sp. nov. (Text-figs. 10 and 11.)

Localities:

Station 158; Maldive area; 786–1170 metres. Two specimens.
Station 159; Maldive area; 914–1463 metres. Five specimens.
Station 184; Gulf of Aden; 1270 metres. One specimen.

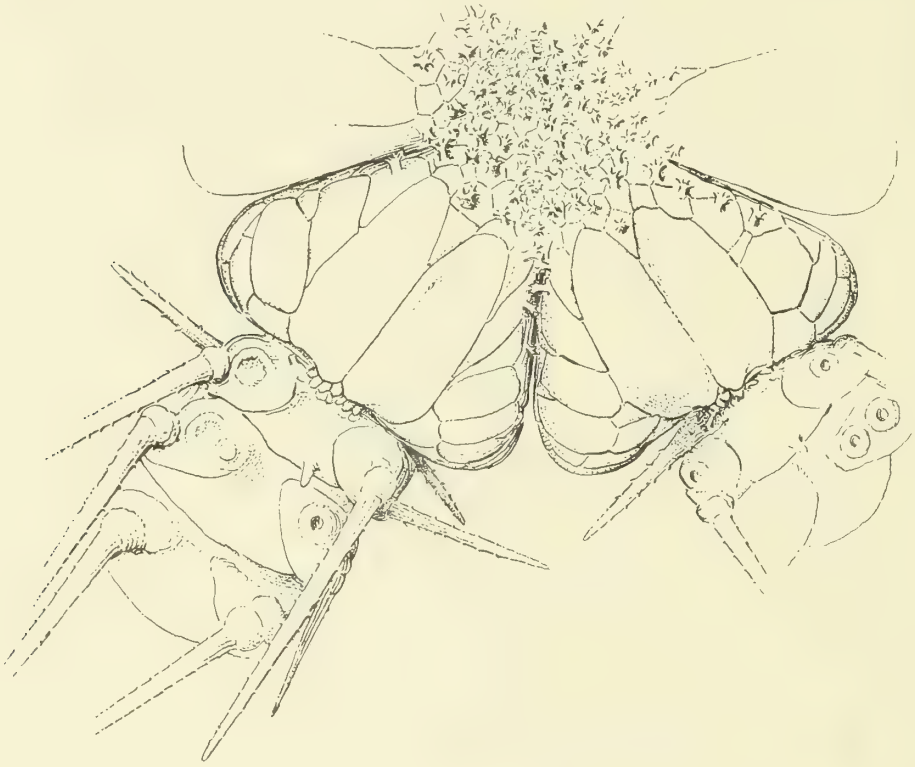
Description.—Disk 10 mm. in diameter, deeply concave at centre, but more than 3 mm. high at margin; the radial wedges of which it is largely made up are over a millimetre higher than the arm-bases, and are more than 5 mm. wide. Centre of disk covered by small and ill-defined scales which are, for the most part, quite concealed by the thorny stumps they bear; these stumps are about half a millimetre high and vary considerably in thickness; if rather slender they usually terminate in 3 very sharp teeth or thorns; but if rather stout, the thorns are shorter and more numerous (4–6), and are not all in the same plane, only one or two being actually terminal; these stumps are most numerous on the central portion of the disk, but a few are scattered on the proximal part of each radial wedge and even in the furrows between them. Each radial wedge is covered by two large radial shields, 3 mm. long by 1·5 mm. wide (distally), broadly in contact except at the proximal end, and 12–15 thin flat plates of very diverse sizes, the largest lying dorsally in contact with the radial shields. At the outer end of each wedge there is a nearly vertical area, some 2 mm. wide and more than a millimetre high, the lateral portions of which are formed by the genital plates; the central portion bears about 20 papillæ decidedly smaller than the disk-stumps and much less thorny; the uppermost papillæ are borne on the distal corners of the radial shields, while the lowest are actually located on the upper surface of the arm-base itself. Arms 5, all broken, but apparently at least 50–60 mm. long in life; they are 2·5 mm. wide. Upper arm-plates well separated from each other even basally, broadly bell-shaped, with a convex distal margin and a pointed inner end; the lateral margins are concave distally, but become convex near the point.

Interbrachial areas below are small and covered with a few flat plates; genital slits wide, especially proximally, where they cause the area to be connected with the oral shield by a very narrow neck. Under arm-plates well separated from each other, wider than long; proximal margin nearly straight, but proximal surface of plate is a little concave; distal margin, noticeably longer than proximal, only a trifle convex, but distal surface of plate is noticeably swollen; lateral margins a little concave. Side arm-plates large, meeting noticeably both above and below; each carries a series of 7 spines which do not approximate dorsally, even on the basal arm-segments. Uppermost spine or the one below it longest, equalling 3 segments; these spines are very delicately thorny, at least near base; the following spines are more thorny and successively shorter, but even the lowest exceeds the arm-segment. The thorniness of the spines is scarcely visible except on magnification of 8 to 10 times. Tentacle-scales single, large, flat, pointed, about as long as under arm-plate and 3 times as long as wide. Oral shields wider than long, diamond-shaped, the two distal margins noticeably thickened; the madreporite is more pentagonal as the distal angle is widened and rounded. Adoral plates short and very wide, meeting broadly within, where they are nearly as wide as at the outer end. Oral papillæ only 3 (rarely 4) on each side, almost subequal; they are thick, narrow and pointed,

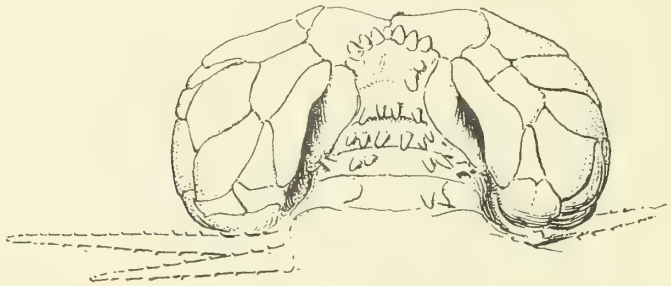
* *papillosus* = bearing papillæ, in reference to the groups of papillæ at the base of each arm.

the innermost is a bit the longest, the outermost somewhat wider and blunter. Lowest tooth like the innermost papilla, but much larger. At the outer end of each mouth-slit, around the tentacle-pore there is some trace of granulation, but there is no heap of granules as in some members of the genus. Colour of dry specimen, white, the arms and spines a trifle more yellowish than disk.

Text-fig. 10.



Text-fig. 11.



Text-figs. 10, 11.—*Ophioplinthaca papillosa* sp. nov. Fig. 10.—Dorsal view of half of disk. × 10. Fig. 11.—View of distal end of radial wedge and upper surface of base of arm. × 10.

Remarks.—The large holotype is a very typical Ophioplinthaca, but it is certainly not *rudis*, although it was taken at the same station with an adult example of that species. The disk covering and the oral papillæ distinguish them at a glance. I have sought in vain among the 25 or more species of Ophioplinthaca that have been named to find one to which I might refer this specimen, but the combination of ophiacanthid oral papillæ with a very typical ophioplinthacoid disk, the narrow but large tentacle-scale, and the low thorny disk-stumps make a unique combination so far as I can see, while the striking

group of papillæ on the distal end of each wedge of the disk is very distinctive. It is true such papillæ occur in some other typical Ophioplinthacas, but in no other species is the group so conspicuous.

The specimens of Ophioplinthaca from Stations 158 and 159 are all young, with disks ranging from 5 to 7 mm. in diameter. In the two specimens from 158 the characters are all essentially the same as in the holotype, but the smaller specimens from 159 show very few, if any, papillæ distal to the radial wedges, and the arm-spines are shorter and more thorny. These differences are undoubtedly those of youthfulness, and there is no doubt that all the specimens are identical with the large individual from Station 184.

Ophioplinthaca tylota* sp. nov. (Text-figs. 12 and 13.)

Locality.—Station 133 ; southern area of Arabian Sea ; 3385 metres. Five specimens.

Description.—Disk 14 mm. in diameter, flat, but a little concave near centre ; radial wedges large and evident, but notches between them not very deep, reaching scarcely half-way to disk-centre ; wedges but little elevated above arm-bases. Radial shields long wedge-shaped, rather narrow and a little depressed, in contact distally, but well separated within. Remainder of radial wedges and central portion of disk covered with numerous overlapping scales of diverse forms and sizes ; the largest are on the distal lateral portions of the radial wedges. On two or three of these large scales on each wedge, a knob-like tubercle is to be found of a very characteristic form ; when young (apparently) these tubercles are spherical and sessile, but the typical ones are bud-like with a short stalk which merges into the ellipsoid tubercle itself ; they are a millimetre or more in length and about ·60 mm. in diameter ; often they are incomplete, the distal end remaining open like a cup or, more rarely, like a shallow bowl. Arms 5, all more or less broken ; the most nearly complete is about 55 mm. long, 3 mm. wide at base, and 2 mm. high ; the complete arm probably exceeded 70 mm. Upper arm-plates of the usual Ophioplinthaca form, much wider than long, with a convex distal margin and the convex lateral margins meeting in a proximal point in the midline ; this point is not quite in contact with the distal margin of the previous plate. The surface of the plate is not evenly arched or rounded, but comes to an elevated but low, blunt or truncate point, just proximal to the centre ; this elevation is not conspicuous, but gives a characteristic facies to each plate ; the first two plates are broadly in contact, but, as already stated, the following do not quite touch.

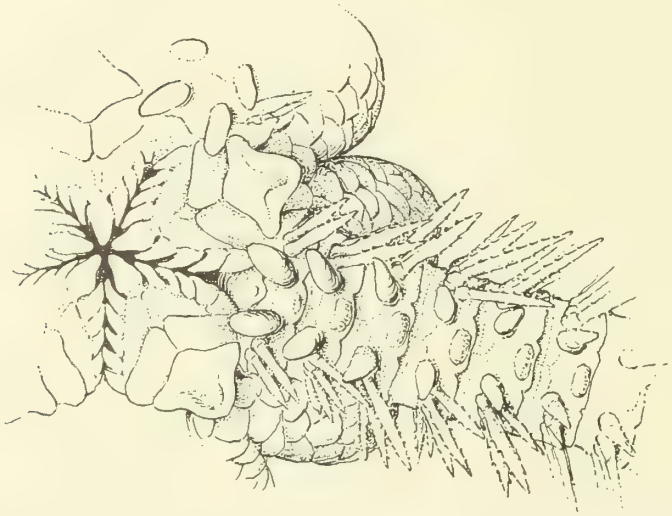
Interbrachial areas below relatively large, quite wide even at the junction with the oral shield, fully covered with coarse, overlapping scales, the distal ones the largest scales in the whole interradial area ; genital slits narrow. Under arm-plates very much wider than long ; proximal portion very narrow, expanding abruptly beyond the tentacle-pores into pointed wing-like processes which nearly reach the sides of the arm ; distal margin of plate 2·5 mm. long, nearly straight, with a conspicuous knob at its middle ; the narrow flat proximal part of the plate with this knob just distal to it is a striking specific character. Side arm-plates of moderate size, meeting narrowly above and below, except at very base of arm ; on the distal half of the arm they meet broadly both above and below ; at tip, the arm is probably somewhat moniliform. On the basal part of the arm each side arm-plate carries 6 rather thick but fragile hollow spines, the uppermost or the one below it

* τυλωτός = knobbed, in reference to the knobs on the disk.

being longest and usually largest; it may equal 3 arm-segments, while the lowest spine little exceeds 1—the spines are quite thorny, especially the lowest ones ; the uppermost is sometimes nearly smooth ; the series of spines encroach but little on the upper side of

Text-fig. 12.

Text-fig. 13.



Text-figs. 12, 13.—*Ophioplinthaca tylota* sp. nov. Fig. 12.—Dorsal view of half of disk. × 6.
Fig. 13.—Oral view of radial wedge and base of arm. × 6.

the arms. Tentacle-scales very thick, heavy and smooth on the basal segments, but they become smaller, flatter and very thorny further out.

Oral shields pentagonal, the inner margins thin and straight, the outer ones conspicuously thickened and curved, the outer, lateral margins deeply concave, the distal

margin convex ; inner angle sharp, the others rounded. Adoral plates large, flat, quadrilateral, meeting broadly within. Oral papillæ only 4 (rarely 3) on each side, rather small, but thick and sharp-pointed. Teeth somewhat larger, thick and bluntly pointed. Colour (dry) silvery white on disk, a more yellowish white on arms.

Remarks.—Considering the great depth from which these three specimens were taken their condition is very good. The two paratypes are about the same size as the one described, but the arms are more badly broken. They differ noticeably from the holotype in the number of bud-like tubercles on the disk. In one there are only 7, and all are relatively small and apparently immature. In the other there are more than 50, but they occur only on the distal or lateral margins of the radial wedges ; they vary much in size, but nearly all have the typical stalked ellipsoid form. This seems to be the best characterized of the new Ophioplinthacas taken by the " Mabahiss ", for aside from the curious disk tubercles, the under arm-plates and tentacle-scales are very characteristic.

Ophiotreta eximia (Koehler).

Ophiacantha eximia Koehler, 1904, p. 116 ; pl. 21, figs. 3–5.
Ophiotreta eximia H. L. Clark, 1915, p. 216.

Localities :

Station 62 ; northern area of Arabian Sea ; 1893 metres. One specimen.
Station 184 ; Gulf of Aden ; 1270 metres. Three specimens.

Range.—Cagayan, Southern Philippines, south to Sumbawa and the Kei Islands, 233–1788 fms.

Notes.—These are well-marked adults, 12–19 mm. across the disk. The largest from the Gulf of Aden has the arms exceeding 150 mm. and the upper arm-spines on the basal part of the arms are 10–12 mm. long ; as there are 10–12 spines on each side-arm plate, and the series approximate closely in the mid-dorsal line, the bristling appearance of this fine Ophiacanthid is very striking. The smallest specimen, from Station 62, is in very poor condition, and the arm-spines are for the most part broken or missing. Comparison of the material with a co-type of Koehler's from near Sumbawa, leaves no doubt as to its identity. The small specimen from Station 62 is a very pale brown or dirty white, but the large specimens from the Gulf of Aden have a distinctly purplish tint, especially the arm-spines. All the specimens are dry.

Remarks.—The extension of range of *eximia* from the East Indies to the Gulf of Aden is notable, especially since it apparently was not met with by the " Investigator " anywhere in the Indian Seas.

Ophiotreta matura (Koehler).

Ophiacantha matura Koehler, 1904, p. 112 ; pl. 23, figs. 2–4.
Ophiotreta matura Koehler, 1922, p. 76 ; pls. 12, 13, 14 and 15, figs. 1–3.

Locality.—Station 184 ; Gulf of Aden ; 1270 metres. One specimen.

Range.—Palawan and Eastern coast of Luzon, south to the Kei Islands, 239–4161 metres.

Notes.—This is a well-preserved adult, 13 mm. across the disk, with arms 65 mm. long, or more. The disk is almost covered with a fairly dense coat of slender spinelets of

uniform length ; the radial shields are completely concealed. The dry specimen is very light yellowish brown on the disk, while the arms have an evident purplish tinge.

Remarks.—The occurrence of this apparently common and very variable species in the Gulf of Aden is a notable extension of its known range, but the occurrence of but a single specimen, and that at the same station with the closely related species *eximia*, is indeed remarkable. The only explanation, of course, is the extremely uncertain chances of dredging, especially in deep water. At Station 184 the length of the haul was 2 hours and 45 minutes, and the area covered may well have included some diversity of habitat, so that these two species of Ophiotreta were not necessarily closely associated in life. It may be worth noting, however, that the "Albatross" took the two species together at two stations, one in Molucca Passage, the other in Buton Strait.

Ophiolimna antarctica (Lyman).

Ophioconis antarctica Lyman, 1879, p. 44 ; pl. 14, figs. 380–382.
Ophiolimna antarctica Matsumoto, 1917, p. 95.

Localities :

Station 120 ; Zanzibar area ; 2926 metres. One specimen.

Station 162 ; Maldive area ; 1824–2051 metres. Eight specimens.

Range.—Extreme Southern Indian Ocean (near Prince Edward, Marion and Heard Islands), 90–270 metres.

Notes.—The specimen from Station 120 is in very poor condition, but is undoubtedly identical with those from the Maldive area. The latter are also in poor condition, but are sufficiently well-preserved to show the essential characters of the species. Comparison with type-specimens of Lyman's species leaves no room for doubt that they are certainly *antarctica*. They measure 6–10 mm. across the disk, and the arms are apparently about four times as much or possibly more. The dry specimens are white.

Remarks.—It is most interesting to find this Antarctic species in the "Mabahiss" collection. In the southern area, where first discovered, it lives in comparatively shallow water, but the bottom temperature was near 2° C. ; at Station 120, the bottom temperature was just over 2° C. ; at Station 162 it was not taken. Although the specimens from the Maldive area extend the known range of this brittle-star some three thousand miles to the north, well across the equator, the environmental conditions (save for pressure) are apparently much the same.

Ophiophthalmus relictus (Koehler).

Ophiacantha relicta Koehler, 1904, p. 106 ; pl. 17, figs. 4–6.
Ophiophthalmus relictus Matsumoto, 1917, p. 106.

Locality.—Station 184 ; Gulf of Aden ; 1270 metres. One specimen.

Range.—Omai Saki Light, Southern Japan, to the vicinity of Rotti and south-western Timor, 538–1624 metres.

Notes.—This is a well-preserved adult, 10 mm. across the disk, with arms about 40 mm. long. The dry specimen is nearly or quite white. The granulation of the disk is sparse and the granules themselves are small and tend to be pointed ; this is somewhat less true of the granules on the upper arm-plates.

Remarks.—The occurrence of this East Indian species in the Gulf of Aden at the

same station with two species of Ophiotreta, also first collected by the " Siboga " is remarkable, since none of the species has been taken in the Indian seas by the " Investigator ". Comparison of a paratype of *Ophiacantha œdidisca* H. L. Clark (1911, p. 219) with this specimen demonstrates their identity, and further comparison with a co-type of *O. relicta* proves that Koehler (1922) was right in relegating the Japanese species to the synonymy of his East Indian form. Matsumoto (1917) and I (1915) both failed to understand Koehler's (1904) description and figures, but in 1922 the eminent French authority made his position perfectly clear.

Ophiotoma assimilis Koehler.

Ophiotoma assimilis Koehler, 1904, p. 144 ; pl. 28, figs. 1, 2.

Locality.—Station 62 ; northern area of Arabian Sea ; 1893 metres. Four specimens.

Range.—South-eastern Luzon, Philippine Islands, south to Rotti and Timor, 402–1033 metres.

Notes.—The specimens at hand are in poor condition and rather small, only 10–13 mm. across the disk. The arms are broken in all, and in only one is the disk covering present. The colour is more or less white ; the only entire disk is greenish grey.

Remarks.—I can find no satisfactory reason for doubting that these Ophiotomas are the same species as those taken by the "Albatross " and well figured by Koehler (1922). The figures given with the original description are rather misleading. It is interesting to note that we have here another " Siboga " species which was not taken in the Indian seas by the " Investigator ", but is found by the " Mabahiss " in Arabian waters.

Koehler (1922, p. 95) has questioned my uniting (1915, p. 217) Lyman's *Ophiacantha bartletti* and *Ophiotoma coriacea*, but a careful re-examination of Lyman's material leads me to think the union is right. The type of *coriacea* is so much larger and more mature than the type of *bartletti* that there is good reason for being uncertain as to the identity, but the reasons given by Koehler are due to his reliance on Lyman's figures, and unfortunately the figure showing the under arm-plate of *coriacea* is inaccurate and hence misleading. The under arm-plates are not essentially unlike those of *bartletti*, and I may add, *assimilis*. The notch in the distal margin of these plates, which Koehler regards as a very particular feature of *assimilis*, is present in all the Ophiotomas I have examined, except possibly the Japanese *megatreta*, where it is nearly or quite wanting. With sufficient well-preserved material at hand, it is quite likely that *assimilis* and *bartletti* would prove to be indistinguishable.

Ophiomyces delata Koehler.

Ophiomyces delata Koehler, 1904, p. 100 ; pl. 17, fig. 9 ; pl. 18, figs. 1, 2.

Locality.—Station 109 ; Zanzibar area ; 640 metres. One specimen.

Range.—Mindanao, Philippines, to Kei Islands, 210–4239 metres.

Notes.—This is a very fine specimen in remarkably good condition. The disk is 8 mm. in diameter and 5 mm. high, and carries a number of scattered spinules, of diverse sizes ; the largest are more than a millimetre long, very slender and acute, a little thorny near base. The arms are 30 mm. long, rather wide at base, but tapering to a slender tip The colour of the dry specimen is nearly white.

Remarks.—Although this specimen does not agree in all details with Koehler's description, it is so nearly like the photographs he published later (1922) that I think it would be foolish to describe it as a distinct species. I must confess myself at a loss to understand Koehler's fig. 13, pl. 96, which is said to represent arm-spines of this species; there is obviously some mistake, either in the text on p. 42, or in the lettering of the plate.

Order **GNATHOPHIURIDA**.

Family **AMPHIURIDÆ**.

Amphiura atlantica Ljungman.

Amphiura atlantica Ljungman, 1867, p. 321.
Amphiura dilatata Lyman, 1879, p. 26; pl. 11, figs. 314–316.
Amphiura atlantica var. *dilatata* Mortensen, 1933*a*, pp. 351–353, figs. 59, 60*b*.

Locality.—Station 113; Zanzibar area; 220 metres. Two specimens.

Range.—St. Helena and coast of South Africa, near the Cape of Good Hope.

Notes.—These specimens are only 3 mm. across the disk (one is diskless) and are in very poor condition, all the arms being twisted and broken, but there is little reason to question the identity.

Remarks.—The identity of Ljungman's and Lyman's species seems to me demonstrated satisfactorily by Mortensen, and I can see no merit in retaining *dilatata* as a variety, the difference in the slenderness of the outer oral papillæ being too slight and untrustworthy a character. The extension of the range of *atlantica* to the Zanzibar area is interesting, but not extraordinary.

Amphiura diomedeæ Lütken and Mortensen.

Amphiura diomedeæ Lütken and Mortensen, 1899, p. 151; pl. 12, figs. 1–7.

Localities:

Station 54; South Arabian coast; 1046 metres. Twenty specimens.

Station 143; Maldive area; 797 metres. Five specimens.

Range.—From the Gulf of Panama and coast of Ecuador to Japan and South Africa, in depths ranging from 70 metres (Japan) to 2877 metres (Ecuador).

Notes.—All of the specimens are small, 3–6 mm. across the disk, but they are for the most part in good condition. The species is notorious for its diversity in mouth parts and other details, so it is not surprising that the specimens from the Maldive area are obviously different from those from the South Arabian coast. The latter have a more delicate appearance with thinner, flatter disk and more delicate mouth parts and arm-plates. The Maldive specimens are stouter with a more porcelain-like finish, and are almost ivory white in colour. The Arabian material has the disks greyish and the arms yellowish white.

Remarks.—Koehler's (1922, p. 159) unwillingness to accept Matsumoto's (1917, p. 198) claim that *diomedeæ* is a synonym of *koreæ* Duncan is amply justified, for Duncan (1879, p. 480) says his species has mouth parts "remarkably like" *Amphiura squamata*. Hence it is clearly an Amphipholis. Moreover he says (p. 466) that the arms are broad,

" not much more than twice the length of the diameter of the body ", while in *diomedeæ* the arms are 5–7 times the disk-diameter. The extension of the range of *diomedeæ* to the Arabian coast is quite to be expected. Its absence from the collections of the " Investigator " is remarkable, and one can but wonder whether it is not identical with *caulleryi* Koehler, which the Indian survey ship took at two stations. As I have seen no specimens of *caulleryi*, however, and Koehler never suggested any similarity between the two species, it would be unwise to assert their identity.

Amphiura grandisquama Lyman.

Amphiura grandisquama Lyman, 1869, p. 334. Mortensen, 1933*b*, p. 452, figs. 19*a–d*.

Locality.—Station 176 ; Gulf of Aden ; 655–732 metres. One specimen.

Range.—Florida and West Indies and eastward across the Atlantic, and south to St. Helena, 18–1850 metres ; Philippine Islands, 77–686 metres ; off Natal, South Africa, 405 metres.

Notes.—This is a large and well-preserved Amphiurid, over 5 mm. across the disk, with arms about 30 mm. long. The dry specimen is nearly white, with the disk somewhat more greyish than the arms. The disk scaling is coarse and the radial shields rather large.

Remarks.—As both Koehler and Mortensen have compared their material from the Philippines and South Africa with specimens from the Atlantic, and consider the identity well established, I record this specimen as *grandisquama*. But comparison with Lyman's type and other western Atlantic material, shows certain differences, particularly in the disk covering that make me think it probable the Indian Ocean form has distinctive characters, which will justify its separation from *grandisquama* when sufficient well-preserved material is available.

Amphiura nociva Koehler.

Amphiura nociva Koehler, 1904, p. 78 ; pl. 15, figs. 3–5.

Locality.—Station 143 ; Maldive area ; 797 metres. Two specimens.

Range.—Known only from "Siboga" Station 251, vicinity of the Kei Islands, 204 metres.

Notes.—These specimens are a little smaller than Koehler's unique type, but correspond to his description and figures with surprising closeness. They are in fairly good condition, though the disk is somewhat damaged in each. Their colour is nearly white. The larger is 5 mm. across the disk, with arms exceeding 30 mm. ; no arm is complete. The other specimen is only a trifle smaller. In both, the upper and under arm-plates have a shining, porcelain-like appearance.

Remarks.—It is a bit strange that this East Indian species was not found by either the "Albatross" or by Dr. Mortensen in their extensive collecting in that region. Its rediscovery by the " Mabahiss " is of very unusual interest. The species is well characterized by its radial shields, upper and under arm-plates, oral shields, adoral plates and arm-spines. The tentacle-scales are very small and on many pores it is very difficult (or impossible) to make out two.

Amphiura uncinata Koehler.

Amphiura uncinata Koehler, 1904, p. 76 ; 1922, pl. 65, figs. 6–8.

Localities :

Station 42 ; South Arabian coast ; 1415 metres. One specimen.

Station 105 ; Zanzibar area ; 238–293 metres. Two specimens.

Range.—Mindoro, Philippine Islands to Java and the Kei Islands, 100–518 metres. Also off Durban, Natal, 405 metres.

Notes.—The specimen from Station 42 is a large one, 10 mm. across the disk, but it is in very poor condition, all the arms being broken at a dozen millimetres from the disk or less. The larger of the two from Zanzibar is 7·5 mm. across the disk, and three arms are more or less complete, the longest about 70 mm. long. They are well over a millimetre wide 15–20 mm. from the disk, and taper very gradually to the broken tips. The smaller specimen is only 4 mm. across the disk ; the arms are slender and broken, the most complete little exceeding 20 mm. As might be expected, the curved (or hooked) spines are not as yet well developed, but otherwise the resemblance to the larger specimens is close. The largest specimen is quite white, the next is more yellowish, while the smallest has the disk very light grey ; the arms white.

Remarks.—The differences between these specimens and Koehler's original description and figures are very considerable, but his later photographs (1922) satisfy me that the " Mabahiss " material should be referred to *uncinata*. There are two causes for doubt, however, for the external oral papilla is more spiniform than in Koehler's (1904) figure and description (even his photograph (1922) does not reveal a really spike-like form), and the interbrachial areas below are more or less completely covered with minute scales. As regards the oral papilla, the three individuals at hand show some diversity ; in the larger Zanzibar specimen the resemblance to Koehler's photograph (pl. 65, fig. 6) is not so hard to see. The covering of the interbrachial oral areas is probably subject to much diversity, associated with breeding conditions and local factors. Unfortunately Koehler (1930) does not give any information concerning the three specimens from the Kei Islands taken by Dr. Mortensen. However, since Mortensen (1933*a*) has referred specimens from Natal to *uncinata*, it seems proper to regard this " Mabahiss " material as representative of the same species.

Amphiura ceramis* sp. nov. (Text-figs. 14 and 15.)

Localities :

Station 33 ; Gulf of Aden ; 1295 metres. Six specimens.

Station 105 ; Zanzibar area ; 238–293 metres. Four specimens.

Station 184 ; Gulf of Aden ; 1269 metres. One specimen.

Station 185 ; Gulf of Aden ; 2000 metres. Three specimens.

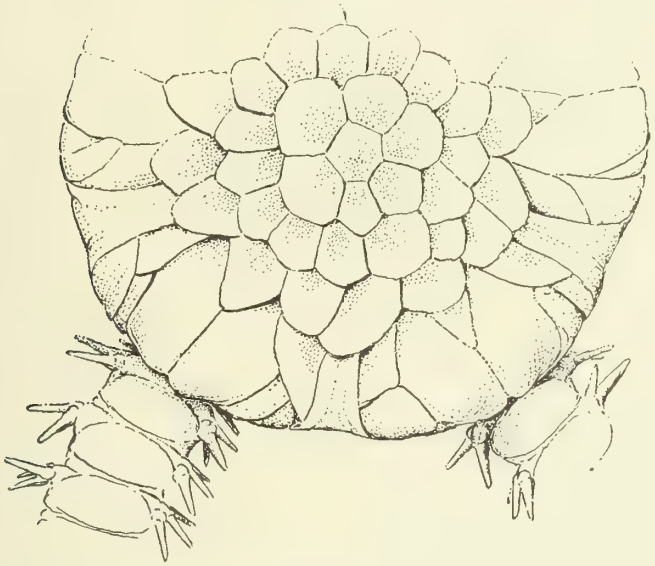
Description.—Disk 7 mm. in diameter, flat and nearly circular ; arms 5, about 35 mm. long, a millimetre wide at base, tapering gradually to the attenuate tip. Disk covered with about 75–80 coarse, flat, overlapping scales and the five pairs of radial shields ; the plates at the centre of the disk are largest and measure fully a millimetre across, yet the 6 primary plates are not well defined ; a large triangular plate separates the inner ends of the radial shields ; interradial areas with three ill-defined series of plates which

* κεραμίς = tile, in reference to the coarse tile-like disk-scales.

tend to be longer than wide. Radial shields large, much longer than wide, the distal portions broadly in contact ; the inner ends conspicuously separated and the outer margins markedly convex. Upper arm-plates rounded quadrilateral or pentagonal, slightly arched, more or less broadly in contact, but all margins ill-defined, much wider than long basally, but becoming longer than wide distally.

Interbrachial areas below fully covered with coarse, flat scales like those of the disk, but smaller. Under arm-plates longer than wide, the first very small, scarcely one-fourth the second, with all angles rounded ; second and following plates with a nearly straight proximal, a slightly convex distal, and concave lateral margins ; they are distinctly but narrowly separated from each other by the meeting of the side arm-plates in the mid-ventral line. The latter do not seem to meet on the upper side of the arm, though they probably do so distally. Each plate carries a series of 3 short arm-spines, thickened at

TEXT-FIG. 14.



TEXT-FIG. 15.

TEXT-FIGS. 14, 15.—*Amphiura ceramis* sp. nov. FIG. 14.—Dorsal view of disk. × 10. FIG. 15.—Oral view of mouth parts and base of one arm. × 10.

base, pointed at tip, the middle one longest, but even at base of arms scarcely as long as an arm-segment. Tentacle-scales 2 at base of arm, small, flat and rounded ; distally the one on the under arm-plate vanishes.

Oral shields small, pentagonal, longer than wide, with a rather sharp proximal angle, the proximal lateral angles also evident, but the distal angles rounded ; distal half of plate much narrower than proximal and markedly depressed, so that at first sight the shield appears to be triangular and wider than long ; madreporite much larger than the others, slightly swollen, and of an irregular rounded form. Adoral plates relatively very large, much longer than wide, meeting broadly within, widest distally where they extend up between the oral shield and side arm-plate. Oral plates not distinct. Oral papillæ conspicuous ; inner pair notably large and block-like, longer than wide ; at distal end of mouth-slit on each side are two rounded scale-like papillæ, much like and little larger than the first tentacle-scales of the arm ; one seems to be attached to the adoral plate, the other to the first under arm-plate ; tentacle-scale of inner oral pore large and noticeable on

three jaws, but apparently wanting on one or two. Teeth conspicuously large and wide, with smooth, rounded margin. Colour of disk, in dry specimen, very pale grey; arms nearly white, with a porcelain lustre.

Remarks.—The holotype, the largest specimen, is from Station 185 in the Gulf of Aden. The other specimen from that station is scarcely 5 mm. across the disk, which has the appearance of being covered by a very delicate membrane, obscuring the outlines of the plates. This is, however, possibly an artefact, as it also conceals the outlines of the oral shields and mouth parts. All the oral papillæ are abnormally small and poorly developed. The specimens from Stations 33 and 184 are also from deep water in the Gulf of Aden. All are relatively small, 2·5–5 mm. across the disk, and agree in nearly all particulars with the type, but in one respect are most perplexingly different. The oral papillæ, aside from the block-like apical pair, shows remarkable diversity in number, form and position. The two rounded scale-like papillæ at the angle of the oral slit are always present, but in every specimen and on nearly all jaws are accompanied by additional papillæ. In most cases the additional papilla which is near the middle of jaw-margin, is similar to the others in form, but is much smaller; sometimes it is narrow and more spiniform. In several specimens still another spiniform papilla is present proximal to the others. In such specimens there are, then, on a single jaw-margin a block-like apical papilla, a conspicuous sharp oral tentacle-scale (at a higher level, of course), a narrow, somewhat spiniform papilla, a small papilla either spiniform or scale-like, and 2 flat, scale-like papillæ. Curiously enough the proximal papillæ are well-spaced and the appearance of the jaw is not as in Amphioplus. The specimens from Zanzibar are all small (3–4 mm. across the disk), but show no diversity in the number or form of the oral papillæ. It is probable therefore that 2 papillæ at the mouth angle is the normal condition, and the individuals with more than that number are "progressive variants". The resemblance of the oral surface of *ceramus* to that of *diomedeæ* is obvious, and it seems best to regard it as a member of that irregular section of the genus Amphiura of which *diomedeæ* is the outstanding representative. When sufficient well-preserved material of the species composing this group, of which several are now known, is available, it is probable that they will be segregated as a distinct genus. Unless this is done it will be increasingly difficult to give a satisfactory diagnosis for Amphiura.

Amphiura crypta* sp. nov. (Text-figs. 16–17.)

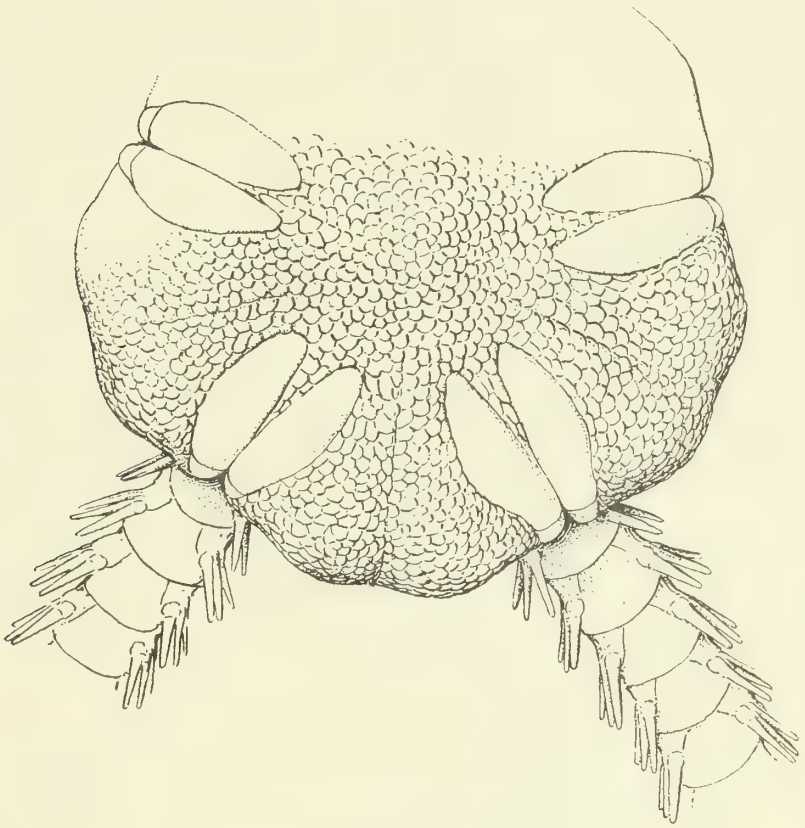
Locality.—Station 24; Gulf of Aden; 73–200 metres. Three specimens.

Description.—Disk 3 mm. in diameter, flat, rounded pentagonal; arms 5, short and relatively stout, all are broken but the longest could hardly have exceeded 12 mm. Disk covered with numerous irregular, overlapping scales of diverse sizes; largest between proximal ends of radial shields, but some on the interradial line near centre of disk are nearly as large; none of the scales are well-defined, as a very delicate membrane seems to cover the whole disk. Radial shields a millimetre in length, about 2·5 times as long as wide, the inner margin nearly straight or a trifle concave, the outer distinctly convex; they are more or less separated from each other except at the distal end. Upper arm-plates rather large, wider than long, with all angles rounded; distal margin convex;

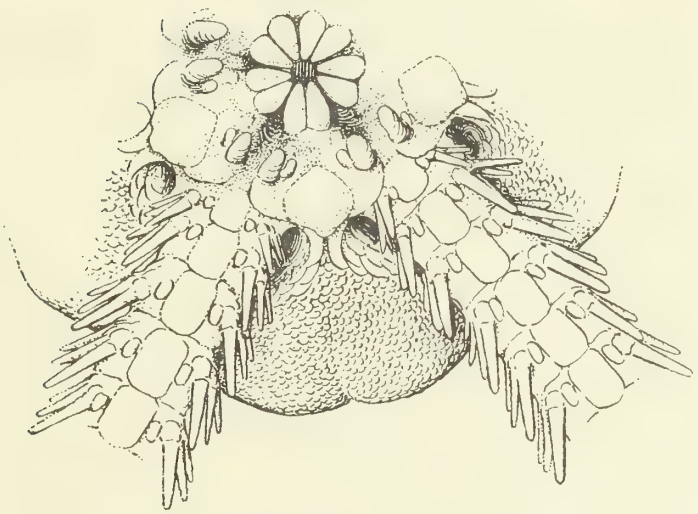
* κρυπτός = concealed, in reference to the obscured oral plates.

proximal margin obscurely narrowed and truncate, but its outline is indistinct ; they are seemingly more or less in contact.

Text-fig. 16.



Text-fig. 17.



Text-figs. 16, 17.—*Amphiura crypta* sp. nov. Fig. 16.—Dorsal view of half of disk and two arm-bases. × 25. Fig. 17.—Oral view of same. × 25.

Interbrachial areas below completely covered with overlapping scales like those of the disk. First under arm-plate small and obscure ; succeeding plates apparently longer than wide, with distal margin convex but notched at middle, the proximal narrowed and

truncate ; apparently they are in contact, but the outlines are not very clear. Side arm-plates moderate, not at all conspicuous ; each carries 4 (or basally 5) terete, smooth, opaque, bluntly pointed spines, the uppermost, equalling the segment, is shortest ; the lowest is abruptly largest and equals a segment and a half or perhaps more. Tentacle-scale single, of moderate size, flat and rounded, too long to be circular.

Oral shields and the whole oral frame with outlines more or less completely obscured by overlying membrane ; this is most marked in the holotype, and least opaque in the smallest paratype ; oral shields are about as wide as long, the madreporite distinctly largest and nearly elliptical. Adoral and oral plates quite obscured. Oral papillæ as usual in the genus, a pair of thick block-like ones at the tip of jaw and an isolated, narrower one at mouth-angle ; this distal papilla is erect, thick, bluntly pointed, two or more times as long as wide. Teeth not noticeable. Colour (dry) pale yellowish white, the disk with a hint of grey.

Remarks.—This little brittle-star cannot possibly be referred to any Amphiurid in this collection, nor can I find any described species to which it may be assigned. The two paratypes are distinctly smaller than the one described, but agree with it in the essentials —the scaling of disk, the radial shields, the upper and under arm-plates, the obscured oral frame, the oral papillæ, the single tentacle-scale and the enlarged lower arm-spine. In one respect, however, they have a very different appearance. In the holotype the arm-spines are appressed more or less closely to the side of the arms ; in the paratypes they are very irregularly bristling. The number of spines is also fewer and the lowest is not so distinctly larger than the others.

Amphiura dejectoides* sp. nov. (Text-figs. 18 and 19.)

Locality.—Station " B ", presumably MB*b* ; Red Sea ; 29 metres. Four specimens.

Description.—Disk 6 mm. in diameter in the dry specimen, but obviously shrunken ; in life it was soft, puffed up, with large interbrachial lobes ; arms 5, much contorted, but not less than 60 mm. long and probably more, tapering slowly to the attenuate tip. Disk covered with very numerous, minute scales ; a few of those close to the proximal ends of the radial shields are markedly larger. Radial shields very long, narrow and somewhat curved, separated from each other, except at distal end, where they may possibly be in contact, but probably not in life ; length 3–4 times the width. Upper arm-plates elliptical, much wider than long, more or less in contact.

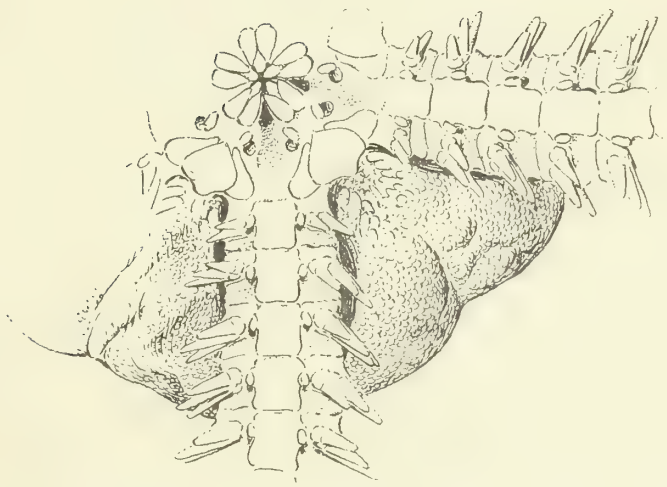
Interbrachial areas below covered with minute scales, but it is possible that near the oral shields the skin is naked, though it is not thin there. First under arm-plate very small and apparently separated from the second by the adoral plates ; second plate much larger, nearly square, with rounded corners ; succeeding plates similar, but a little larger and becoming longer than wide ; all are in contact with each other or separated by a narrow groove ; distal end becomes wider than proximal. Side arm-plates not large or conspicuous, and apparently not meeting either above or below ; each plate carries a series of 5 stout spines, the lowest is pointed and is longest, except on the basal arm-segments, and distally exceeds them ; the uppermost is shortest, blunt and somewhat flattened ; the other three are intermediate in size and form, but one or two may have the tip thickened or widened. As the spines stand out at right angles from the arms, the latter are quite

* *dejectoides* = like *dejecta*, an East Indian species which it resembles in many features.

bristling. Tentacle-scale single, flat and rounded, rather large at base of arm, but distally it is small.

TEXT-FIG. 18.

TEXT-FIG. 19.



TEXT-FIGS. 18, 19.—*Amphiura dejectoides* sp. nov. FIG. 18.—Dorsal view of half of disk and an arm-base. × 20. FIG. 19.—Oral view of same. × 20.

Oral shields, and the whole oral frame, with outlines rendered more or less indistinct by overlying skin. Oral shields small, pentagonal, wider than long, with all angles rounded. Adoral plates short and wide, not meeting within, but sometimes meeting radially between

the first and second under arm-plates ; this meeting is not very complete and probably is not so marked in living or well-preserved material. Oral plates small. Inner oral papillæ thick, more or less pointed, not very large ; outer ones slender, blunt and erect. Teeth not very wide or conspicuous with a rounded or nearly straight margin. Colour of disk in dry specimen pale grey ; arms yellowish white, but there is no marked contrast.

Remarks.—Of these four specimens, three are much alike in size, colour and general appearance, but the fourth is much younger, only 4 mm. across the disk, which is somewhat darker coloured than in the large specimens. All are in poor condition with the long arms badly contorted.

The presence of a single tentacle-scale, the five arm-spines, and the form of the oral shields led at first to the conclusion that these brittle-stars were examples of Koehler's (1922, p. 154) species *dejecta*, known only from a single specimen from Borneo. But the differences in disk and disk-covering and in the outer oral papilla preclude such a decision, which is further negatived by the much greater depth at which *dejecta* was taken. The Red Sea species is obviously one of the long-armed, mud-loving, shallow-water Amphiurans, and seems to be quite distinct from any previously known.

Amphiura eugenioides* sp. nov. (Text-figs. 20 and 21.)

Locality.—Station 54 ; South Arabian coast ; 1046 metres. One specimen.

Description.—Disk 2 mm. in diameter, flat, nearly circular ; arms 5, about 16 mm. long. Disk covered with numerous overlapping scales among which the 6 primary plates are easily distinguished. Radial shields small, about twice as long as wide, well separated within, but more or less nearly in contact distally. Upper arm-plates a little longer than wide, with distal margin convex and proximal end truncate, more or less clearly in contact.

Interbrachial areas below fully covered with small scales. Under arm-plates oblong with rounded corners, longer than wide, the distal margin a little concave, the proximal a trifle convex, broadly in contact. Side arm-plates not notable, each with 5 or 4 short, pointed, nearly equal arm-spines about as long as a segment ; they stand out at right angles to the otherwise narrow arm. Under high magnification ($\times$ 90) one or two in each series, near base of arm, show a distinct hyaline tooth projecting laterally from the tip, but this is so inconspicuous it might be easily overlooked. Tentacle-scales 2, of rather small size ; distally the one on the under arm-plate seems to be wanting.

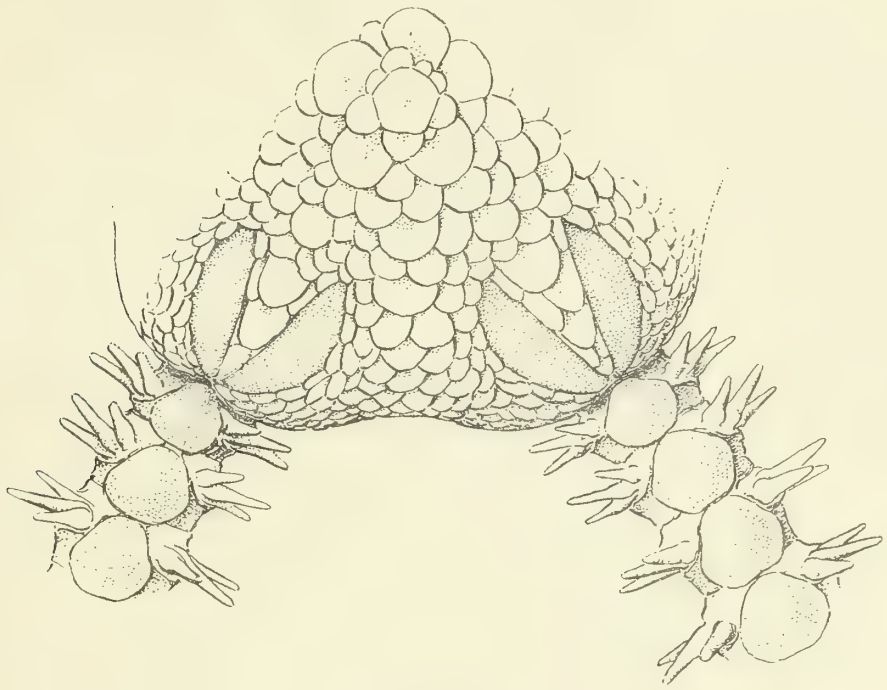
Oral shields oval or rounded pentagonal, narrowest distally, bluntly pointed within. Adoral plates, short and wide, apparently not quite meeting within. Oral papillæ 2 or 3 on a side ; the usual thick, block-like proximal pair, a relatively large flat, oval distal scale, and usually a similar but much smaller scale, distal to it. This arrangement is much as in *diomedeæ*, but the scales themselves have a very different shape. Colour (dry) of disk very pale grey, the arms more nearly white.

Remarks.—This little Amphiura is so exactly like *A. eugeniæ* Ljungman that a detailed description would be quite superfluous if that species had ever been adequately described. Were the " Mabahiss " specimen from the South Atlantic near South America it would be referred to *eugeniæ* without hesitation. I have compared it carefully with specimens of *eugeniæ* from off La Plata and with a fine specimen from the Falkland Islands,

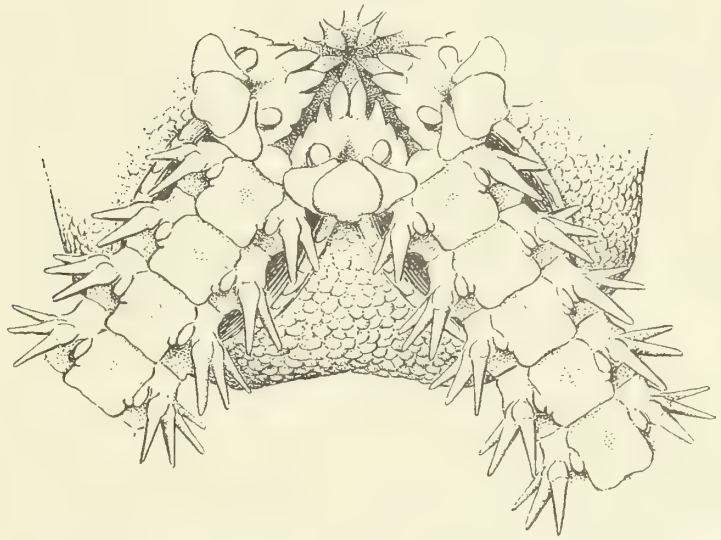
* *eugenioides* = like *eugeniæ*, a South Atlantic species which it much resembles.

and I can find no important differences. Besides the tooth at the tip of some arm-spines, which I have not found in *eugeniæ*, the only difference is in the surface of the interbrachial areas ; in the South Atlantic species, the scales are a trifle swollen, so the surface seems very

TEXT-FIG. 20.



TEXT-FIG. 21.



TEXT-FIGS. 20, 21.—*Amphiura eugenioides* sp. nov. FIG. 20.—Dorsal view of part of disk and two arm-bases. × 30. FIG. 21.—Oral view of nearly half of lower surface. × 30.

finely granular, while in the Arabian specimen the surface is smooth. This difference may well be a youthful character, as the " Mabahiss " specimen is much smaller than any of the *eugeniæ* at hand. Owing to the extraordinary geographical difference in occurrence it seems unwise to list the Arabian specimen as *eugeniæ*. By calling it *eugenioides* its

resemblance to the South American form will be emphasized, and the above description will be of assistance in identifying Ljungman's species.

Amphiura megalaspis* sp. nov. (Text- figs. 22 and 23.)

Locality.—Station 54 ; South Arabian coast ; 1046 metres. One hundred and forty-two specimens.

Description.—Disk 6 mm. in diameter, flat, rounded pentagonal ; arms 5, all broken, but, judging from other specimens, about 30 mm. long, tapering to an attenuate tip. Disk covered chiefly by the 5 pairs of relatively huge, thin, radial shields ; each shield is about 2·5 mm. long by 1·5 mm. wide at distal margin, its proximal end bluntly pointed, or more or less rounded ; each pair of shields forms a radial wedge, suggestive of Ophioplinthaca, though there are no interradial furrows ; the centre of disk and the narrow interradial areas are covered by crowded, thin, overlapping scales of moderate size. Upper arm-plates broadly oval, as wide as long or wider ; the narrower proximal end is more or less truncate where in contact with the strongly convex margin of the preceding plate.

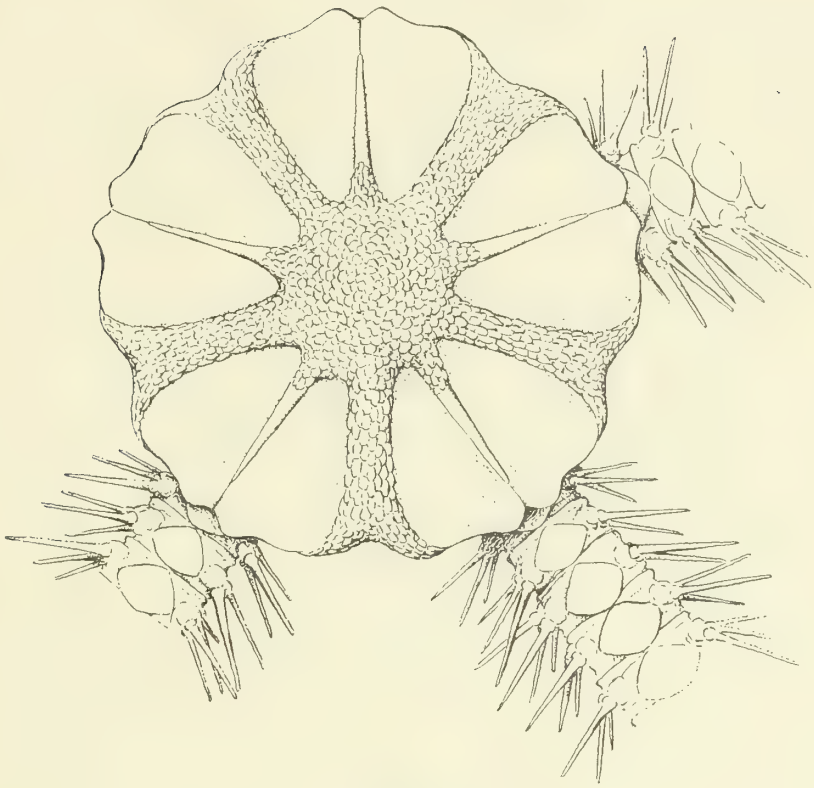
Interbrachial areas below fully covered with thin plates. First under arm-plate pentagonal, rather broadly in contact with the second, which, like the succeeding plates, is markedly longer than wide ; all are thin and more or less in contact ; each plate is narrower proximally than distally and is raised into a low but rather evident keel along the mid-line ; all angles are rounded. Side arm-plates small ; each carries 4 (at base of arm, 5) slender, acute, fragile arm-spines, of which the lowest is longest and equals or exceeds two arm-segments. Tentacle-scale single, rather large, flat, thin and elliptical or nearly circular.

Oral shields rather large, especially the madreporite, much wider than long, the inner margin convex, the outer projecting as a rounded lobe. Adoral plates small, about 3 times as long as wide, lying on the inner margin of the oral shield, but not meeting in the mid-line. Oral papillæ conspicuous but rather delicate ; inner pair, somewhat block-like, but the tip is obliquely pointed, or notched, with a large point on one side and a small one on the other ; distal papilla slender, erect, acute, three times as high as base width. Tentacle-scale of inner oral pore conspicuous, triangular, sharply pointed. Teeth narrow, with convex margin. Colour of disk (dry) pale grey ; arms more nearly white.

Remarks.—This species is undoubtedly nearly related to *grandisquama*, but is easily distinguished by the huge radial shields. These, with the long arm-spines, give the appearance of an Ophiacanthid, especially Ophioplinthaca, but the oral surface promptly dispels such an illusion, as the resemblance there to *grandisquama* is obvious. The whole structure is, however, much more delicate and fragile than in that species, and suggests at once a deep-water habitat. Most of the material is in poor condition and shows little diversity in either size or appearance. It is divided into six lots (Op. 48, 70, 89, 126, 168, 174), of which No. 70 is a single specimen, the holotype. With 48 (2 specimens) is a field note (46) which says : "A sample of very soft rock evidently bored by some animal which has now been exterminated. The holes were occupied by a sparse secondary fauna, consisting mostly of Polychæts, with an occasional mollusc or ophiuroid. The rest of the catch consisted of mud-dwelling forms." With 168 (2 specimens) is a field note (151) saying : " Worms, worm-tubes, 2 ophiuroids, 1 barnacle and 1 hydroid from ' Apple-sponge '."

* μέγας = big + ἀσπίς = shield, in reference to the huge radial shields.

TEXT-FIG. 22.



TEXT-FIG. 23.

TEXT-FIGS. 22, 23.—*Amphiura megalaspis* sp. nov. FIG. 22.—Dorsal view of disk and three arm-bases. × 12. FIG. 23.—Oral frame, two arm-bases and an interbrachial area. × 12.

AMPHIONCUS* gen. nov.

Amphiurids with flat disk and arms, large radial shields, naked interbrachial areas below, conspicuously swollen oral plates, and the inner of two distal oral papillæ and the outer of the two tentacle-scales prolonged into a conspicuously-barbed spine.

* *Amphi*, the generic prefix common in this family + ὀγ′κυς = a barb, in reference to the strongly-barbed tentacle-scales.

Genotype : *Amphioncus platydiscus* sp. nov.

The remarkable barbed tentacle-scales (the inner oral papilla being, of course, homologous), the swollen oral plates, and the naked oral interbrachial areas, of the notably flat disk give this genus a very characteristic facies. It is probably to be considered a specialized Amphiura, related to the *diomedeæ* group, rather than to Amphiodia, as the distal oral papillæ might suggest. In some particulars it reminds one of Amphilepis, but it is not very near that genus.

Amphioncus platydiscus* sp. nov. (Text-figs. 24, 25 and 26.)

Locality.—Station 16 ; Gulf of Aden ; 186 metres. Five specimens.

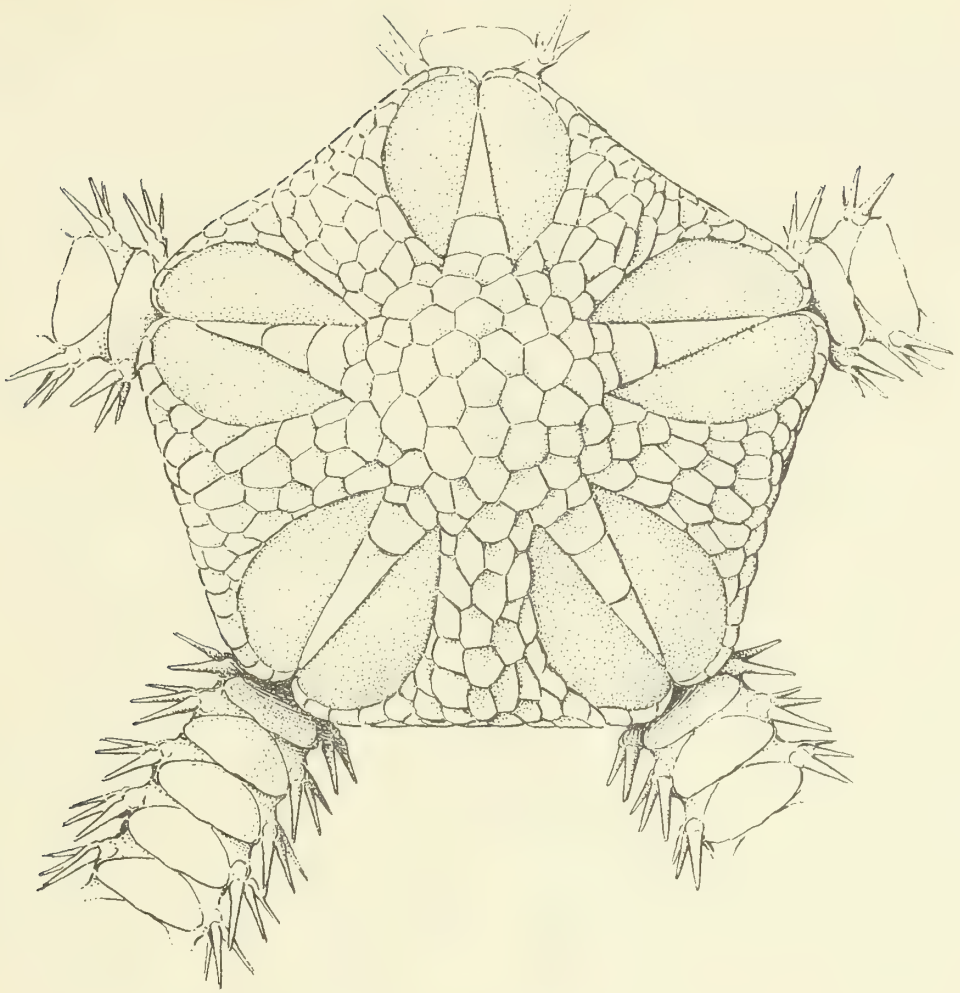
Description.—Disk 7 mm. in diameter, very flat and thin, pentagonal with concave sides and rounded radial angles. Arms 5, rather wide and flat basally, but tapering to a more or less attenuate point, probably (to judge from the paratypes) about 40 mm. long. Disk covered with large, thin overlapping scales, among which the primary plates can, with more or less difficulty, be distinguished. Radial shields large, 2 mm. long by 1 mm. wide ; outer margins convex, inner straight ; the shields are in contact at the distal tips, but diverge considerably so that they are separated by a series of two or three plates, the outermost long, narrow and pointed, and sometimes divided transversely into two, the inner wider than long, with somewhat rounded distal corners. Upper arm-plates large, thin, covering pretty completely the upper surface of arm ; each plate is very much wider than long, with a nearly straight distal margin and a broadly convex proximal side ; some of the plates have short lateral margins, but all angles are rounded ; the plates are more or less in contact, especially at base of arm, but there is much diversity in this detail associated with the flexure of the arm.

Interbrachial areas below covered with a thin naked skin. Under arm-plates much wider than long ; at base of arm they are definitely hexagonal, with a short proximal side in clear contact with the preceding plate ; this is particularly marked between the second plate and the much smaller first, which is scarcely half its size ; distally the side arm-plates crowd in more and more, but it is only far out on the arm that they actually separate the now pentagonal under arm-plates entirely. Side arm-plates small, each with 3 slender, acuminate spines, the middle one usually longest and exceeding the segment ; it is sometimes noticeably widened or thickened at the base. Tentacle-scales 2, of striking appearance ; the inner, lying along the margin of the under arm-plate, is flat and scale-like, longer than wide ; the outer is wide and flat basally where attached to the side arm-plate, but it narrows rather abruptly into a conspicuously barbed spine. This remarkable tentacle-scale is about one-third as long as the arm-segment.

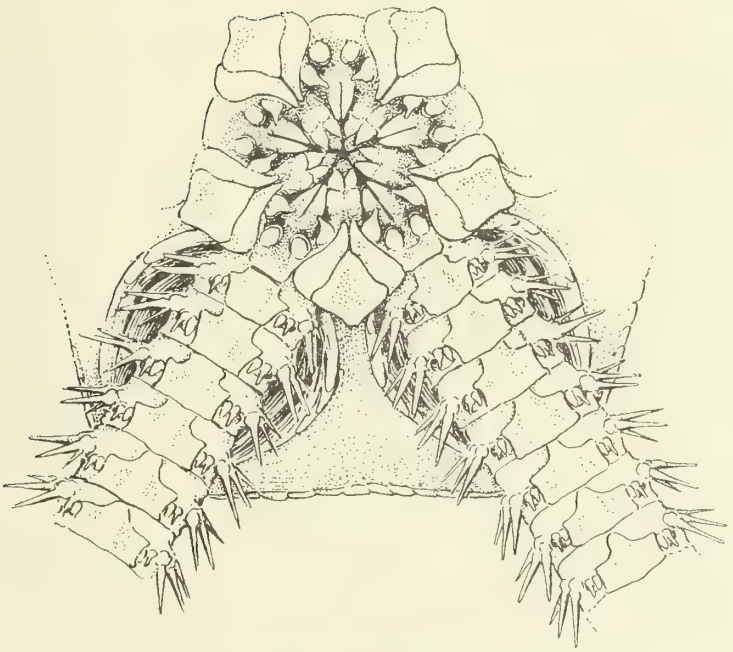
Oral shields rather large, diamond-shape, about as wide as long ; angles slightly rounded and distal one sometimes truncated. Adoral plates large, rounded distally and wider without than within where they meet. Oral plates large, swollen proximally and apparently fused into a single mass on which are borne the pair of block-like, but somewhat pointed, apical oral papillæ. Oral tentacle-scale conspicuously large, thick and pointed. Distal oral papillæ 2 on each side, the outer flat and rounded, the inner like the outer tentacle-scale, but the barbs on the narrowed point are not so long and conspicuous. Teeth thick, rather abruptly narrowed into a rounded point. Colour of disk (dry) pale

* πλατύς = flat + δίσκος = disc, in reference to the very flattened body.

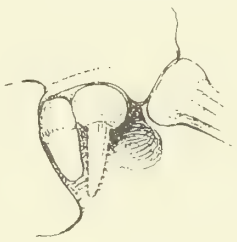
Text-fig. 24.



Text-fig. 25.



Text-fig. 26.



Text-figs. 24–26.—*Amphioncus platydiscus* sp. nov. Fig. 24.—Dorsal view of disk and two arm-bases. × 14. Fig. 25.—Oral frame, two arm-bases and an interbrachial area. × 14. Fig. 26.—Tentacle-pore at base of lowest arm-spine, showing the pair of tentacle-scales. × 75.

grey ; the margins of the scales are usually lighter than the centre, but this contrast is seldom marked ; the arms are more nearly white ; the interbrachial areas below are dark grey or brown, or even blackish, in marked contrast to the white genital scales on each side.

Remarks.—The four paratypes are very similar to the one described, and all are of nearly the same size. They show little diversity in any details, even the scaling of the disk being quite similar in all.

ANAMPHIURA* gen. nov.

Amphiurids with coarse disk-scales, some of which, especially on the interradial margins, carry spinelets ; primary plates conspicuous ; jaws with apical oral papillæ as in Amphiura, but irregular in number (2 or 3), size and position ; 2 or 3 distal oral papillæ, flat and rounded, surround the second oral tentacle ; papilla of first oral tentacle unusually large and conspicuous, sharply pointed ; tentacle-scales 2 or 3 on basal arm-segments, but single and large, as in Ophiactis, on most of arm.

Genotype : *Anamphiura valida* sp. nov.

This striking novelty at first suggests Ophiactis, by its form, arm-spines and tentacle-scales, but the presence of apical oral papillæ prevents close association with that genus. It seems probable that the nearest relatives are those Amphiuras like *diomedeæ*, which have more than a single distal oral papilla, but the general facies of this ophiuran is so different from those Amphiurids, it cannot be associated with them at all closely. It is evidently an aberrant and apparently still unstable form, whose oral characters are not yet firmly fixed.

Anamphiura valida† sp. nov. (Text-figs. 26A and 27.)

Locality.—Station 105 ; Zanzibar area ; 238–293 metres. Four specimens.

Description.—Disk 5 mm. in diameter, somewhat circular, but deep radial notches for the insertion of the arms make it appear 5-lobed ; it is distinctly elevated, the vertical diameter being more than a millimetre. Arms 5, only 11 mm. long ; about a millimetre wide at base, but tapering steadily to a flattened attenuate tip. Disk covered by a coat of coarse scales, most of which are slightly convex ; primary plates very conspicuous ; the group is nearly 2·5 mm. across and the central plate is ·80 mm. ; in one interradius there is a large plate separating two of the radials, while it is itself separated from the central plate by 2 small plates ; this condition is abnormal, as the paratypes show the primary plates in a symmetrical group of 6. Radial shields small, elliptical, about ·80 mm. long by ·40 mm. wide ; they lie in closely appressed pairs, but slightly separated proximally by a small triangular scale and distally by the first upper arm-plate. Scattered very irregularly over the disk are about 30 slender, acute spinelets, most numerous near the margin of the interradial lobes ; these spines are nearly always borne on very small plates. First upper arm-plate small and triangular, separating distal ends of radial shields ; second plate (on which the first seems to rest) is also within the disk, oblong, in broad contact with third, which is also wider than long ; succeeding plates nearly circular,

* ἄν, primitive + Amphiura, in reference to its relationship to, but obvious distinction from, that genus.
† *validus* = strong, well established; of obvious appropriateness.

conspicuously swollen, about as wide as long, but with the proximal margin slightly extended to touch the preceding plate ; distally they become flat and well separated, and are then broadly diamond-shape, with the lateral and distal angles rounded.

Interbrachial areas below, large, well-covered with scales, many of which bear slender, acute spinelets. Genital slits well-marked. First under arm-plate relatively large, oblong, longer than wide, broadly in contact with the second plate ; succeeding plates much longer than their median width, but so wide distally that the somewhat convex distal margin equals the length ; the narrow proximal end is fully in contact with preceding plate ; lateral margins concave, due to the very large tentacle-pores ; median area of plate, especially distally, somewhat swollen. Side arm-plates large, stout and projecting, meeting more or less fully above except at base of arm ; each plate carries 5 (rarely 6) slender acuminate spines, of which the lowest is biggest and longest, equalling or exceeding

TEXT-FIG. 26A.

TEXT-FIG. 27.

TEXT-FIGS. 26A, 27.—*Anamphiura valida* sp. nov. FIG. 26A.—Dorsal view of half the disk and one arm-base. × 14. FIG. 27.—Oral view of half of lower surface. × 14.

the arm-segment ; uppermost is smallest, equalling about one-half the segment. Tentacle-pores very large ; on the first three on each side there are 3 or 2 flat, rounded scales, 1 or 2 on the side arm-plate, and 1 on the under arm-plate, but beyond the third segment (*i.e.* outside the disk), there is only one large, nearly circular scale, borne on the side arm-plate ; the scale on the under arm-plate has disappeared.

Oral shields diamond-shape, wider than long, made pentagonal by the truncation of the distal angle ; the two distal sides are made strongly concave by the end of the genital slit. Adoral plates large, meeting fully within, where they are a little narrower than at the outer end, which rests against the first under arm-plate. Oral papillæ conspicuous in two groups ; at apex of jaw are 2 (on two jaws, 3) pointed, block-like papillæ, not in close contact with each other ; in the paratypes there are always 2, except on one jaw, which has but 1 ; on adoral plate, at outer end of mouth-slit, are 3 flat, scale-like papillæ, the middle one largest and most pointed ; this group corresponds almost exactly to the tentacle-scales of the first arm-pore. Tentacle-scale of first oral pore very conspicuous, long and pointed. Teeth rather narrow, especially the lowest, with rounded, barely

notched margin. Colour (dry) of disk, glistening ivory white ; arms with a very faint tint of brownish.

Remarks.—This well-marked ophiuran is easily distinguished even in so perplexing a family, by the general facies, the spinulose disk, the arm-plates and the still somewhat generalized mouth parts. The paratypes are 3·5–4·5 mm. across the disk, and agree closely with the holotype in nearly every way.

AMPHIOMYA* gen. nov.

Similar to Amphipholis, but having the tentacle-scales so arranged that they suggest by form and position the two valves of a small clam.

Genotype : *Amphiomya notabilis* sp. nov.

The peculiar arrangement of the tentacle-scales quite warrants a new genus for this Amphiurid, even though there is but one specimen at hand, and that a small one. Fortunately it is in excellent condition.

Amphiomya notabilis† sp. nov. (Text-figs. 28 and 29.)

Locality.—Station unknown. The only label with the specimen is " Op. 11 ". In the list of Ophiuran lots, Op. 11 is marked " no label ". As Op. 10 was taken February 15th, 1934, and Op. 12 October 29th, 1933, it is evident nothing is indicated by the " 11 ", as to either time or place.

Description.—Disk 3·5 mm. in diameter, nearly circular, a trifle convex. Arms 5, slender, 20–25 mm. long. Disk covered by a close coat of rather coarse (relatively), overlapping scales. Radial shields small, about ·75 mm. long and ·30 mm. wide ; they are closely appressed in pairs, only the proximal tips being slightly separated by one or two minute scales. Upper arm-plates relatively large, somewhat convex, rounded triangular or somewhat pentagonal, all angles rounded or proximal one, truncate ; distal margin longest, full width of arm, somewhat convex ; all plates are slightly in contact where truncated proximal angle meets the margin of preceding plate.

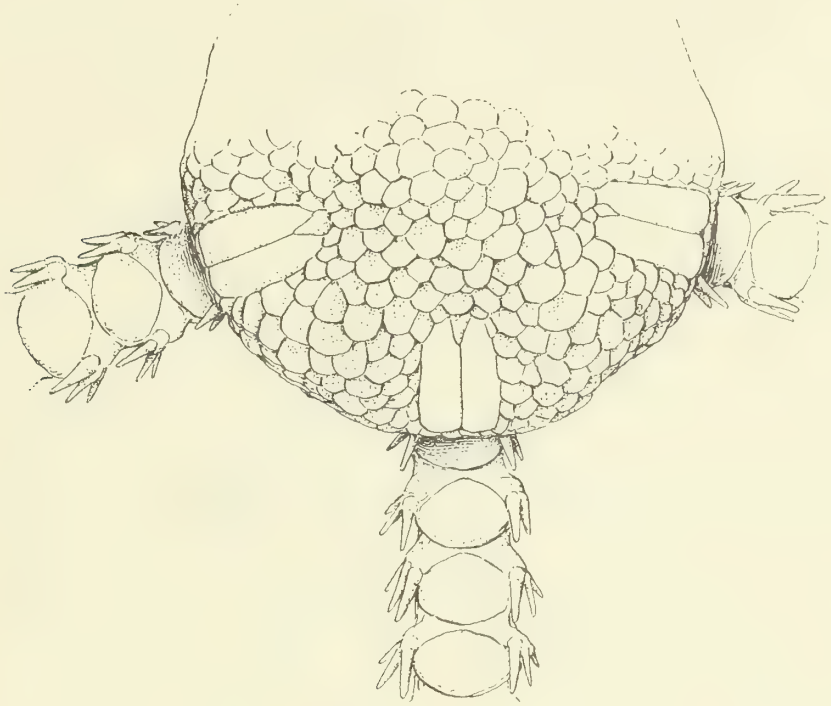
Interbrachial areas below wide, densely covered with small but thick plates. First under arm-plate pentagonal, longer than wide, small but completely separating the adorals, and distinctly in contact with the second plate, which is also pentagonal, but about four times as large, and as wide as long ; succeeding plates similar, but wider than long, with straight distal margin and sides, and a rather blunt proximal angle. Side arm-plates large but mainly oral, completely and widely separating the under arm-plates, but not quite in contact above. Each bears 3 short, subequal, thick, bluntly pointed arm-spines not much more than half as long as a segment ; they are often appressed to the arm, but may stand out at right angles. Tentacle-scales 2, relatively large, more or less circular and concave, like minute clam-shells ; the smaller is attached to the side arm-plate close to the proximal end of the lateral margin of the under arm-plate ; the larger is also apparently borne on the side arm-plate with its inner edge adjoining and possibly attached to the under arm-plate ; if the tentacle is not extended, the two scales may be shut together

* *Amphi*, the generic prefix common in this family + μῦς = mussel, a bivalve mollusc in reference to the curious clam-like arrangement of the tentacle-scales.

† *notabilis* = worthy of note, in obvious reference to its unusual features.

like a clam-shell. The lowest arm-spine, which is very short within the disk, is just outside the tentacle and looks like a third, thick tentacle-scale on the first 3 or 4 arm-segments.

Text-fig. 28.



Text-fig. 29.

Text-figs. 28, 29.—*Amphiomya notabilis* sp. nov. Fig. 28.—Dorsal view of half the animal. × 20. Fig. 29.—Oral view of mouth parts, 2 arm-bases and an interbrachial area. × 20.

Oral shields diamond-shape, longer than wide, the proximal angle acute, the others rounded; madreporite conspicuously swollen, with all angles rounded. Adoral plates large, meeting broadly within, where they are only a little less wide than at the outer end, where they meet the first under arm-plate and side arm-plates. Oral papillæ, notably thick, arranged as in Amphipholis; a high block-like pair at tip of jaw; a second papilla

of about equal width on side of jaw and a third distal papilla fully twice as wide as long, its width equalling or exceeding the two proximal papillæ. Teeth not visible. Colour pale greyish white.

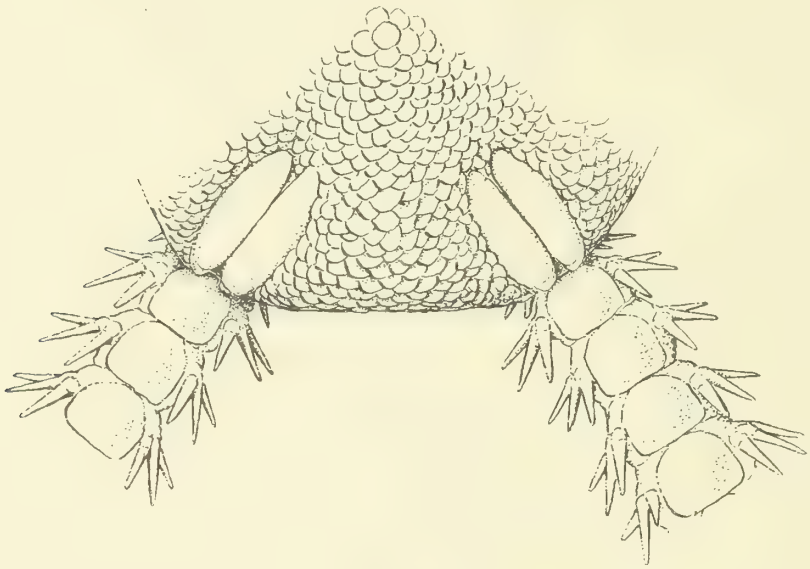
Remarks.—It is, of course, most regrettable that this unique specimen has no locality label. From its general structure and appearance, it is a shallow-water form, and it is not unlikely that it came from the Maldive area, where considerable shallow water collecting was done. Its relationship to Amphipholis is, of course, obvious.

Amphiodia minuta* sp. nov. (Text-figs. 30 and 31.)

Locality.—Station 142B ; Maldive area ; 37 metres. Two specimens.

Description.—Disk 2·5 mm. in diameter, nearly circular, almost flat. Arms 5,

Text-fig. 30.



Text-fig. 31

Text-figs. 30, 31.—*Amphiodia minuta*. × 30.

exceedingly long and slender ; all are broken, but one is fully 25 mm. long and shows only a little attenuation at the broken tip ; there is little doubt that in life the arms were

* *minutus* = very small, of obvious application.

fifteen times the disk diameter. Disk covered by a very close coat of minute overlapping scales, with no indication of primary plates. Radial shields small, half a millimetre long, in closely appressed pairs ; each pair in hardly one-third of a millimetre wide. Upper arm-plates large, broadly oval, wider than long, the distal margin somewhat convex, the proximal angle rounded ; they are in contact basally, but become more or less separated distally by the side arm-plates.

Interbrachial areas, closely covered, like the disk, with small overlapping scales ; genital slits large. Under arm-plates oblong, the first relatively large, about one-half the second, with which it is in contact ; succeeding plates about as wide as long, but soon becoming distinctly longer than wide, with concave lateral margins and rounded angles ; they are more or less in contact until well out on the distal part of arm. Side arm-plates small ; each carries 3 slender acute spines, of which the middle one is stoutest and slightly exceeds the arm-segment ; the lowest is as long but more slender, the uppermost is evidently shorter. Tentacle-scale single, small and rounded, placed near the middle of the lateral margin of the under arm-plate ; it is clearly developed only on the basal arm-segments, and is apparently wanting distally.

Oral shields oval, longer than wide, widest distally, the inner end a rounded point, the outer somewhat truncate. Adoral plates indistinct, so that it is difficult to determine their true form ; the outer portion is triangular, with a point touching the first under arm-plate and the outer side resting against the side arm-plate ; apparently they do not meet within, though in some cases the proximal portion extends inwards along the oral shield. Oral papillæ as usual in Amphiodia, but notably thick and stout ; the innermost pair are bigger than the second ; the outermost are widest and most flattened and scale-like ; they have a rounded margin ; the three of any one side of a jaw are in close contact with each other. Teeth of moderate width, with slightly concave margin. Colour (dry) pure white.

Remarks.—The second specimen is diskless, but in other respects is just like the holotype. They have every appearance of being adults, and not the young of a larger species. The radial shields, oral shields and excessively long arms are distinctive.

Amphioplus hastatus (Ljungman).

Amphipholis hastata Ljungman, 1867, p. 313.
Amphioplus hastatus H. L. Clark, 1915, p. 257. Koehler, 1926, pl. 3, figs. 2 and 3.

Localities :

Station 45 ; South Arabian coast ; 38 metres. Seven specimens.
Station 89 ; northern area of Arabian Sea ; 135–183 metres. One specimen.
Station 206 ; Red Sea ; 256 metres. One specimen.
Station MB IIc ; South Arabian coast ; 29 metres. One specimen.

Range.—Mozambique and East Indies near Ceram and Banda, in shallow water.

Notes.—All of the specimens are small and many are in poor condition, but they show the species characters well. The largest is from Station 206 and measures a full 5 mm. across the disk ; it is therefore the largest specimen yet taken ; unfortunately the arms are all broken near the disk. The specimen from Station MB IIc is the smallest, but is in excellent condition ; the disk is less than 2 mm. across, while the slender arms

are fully 10 mm. long. The remaining specimens are 3–3·5 mm. across the disk, but the only one with an arm even approximately whole is diskless !

Remarks.—Koehler (1926, p. 16) states that the specimens taken by the " Siboga " were " parfaitement identique " with one of Ljungman's types with which he compared it, so it is evident that the species ranges from Mozambique to Banda. It is not strange, therefore, that the " Mabahiss " met with *hastatus* in her dredging, but it is odd that all of the material came from the northern part of her collecting field, and no specimens were met with in the Zanzibar area. Since it is a shallow water species, the reverse might have been expected.

Ophiactis carnea Ljungman.

Ophiactis carnea Ljungman, 1867, p. 324. Mortensen, 1933a, p. 343, fig. 54.

Localities :

Station 45 ; South Arabian coast ; 38 metres. Ninety-three specimens.
Station 53 ; South Arabian coast ; 13·5 metres. Two specimens.
Station MB II*a* ; South Arabian coast ; 11 metres. Five specimens.

Range.—Coast of South Africa, low-water mark to 225 metres.

Notes.—The specimens from Stations 53 and MB II*a* are very young with disk-diameters of 1 to 2·5 mm. The series from Station 45, however, is a very diversified lot of material. It was included under 13 lot numbers (Op. 14, 15, 33, 88, 101, 113, 119, 124, 140, 142, 156, 166, 191) with " notes " in half a dozen cases, indicating how large an amount of bottom material (sponges, alcyonarians, etc.) was secured at Station 45, and how patiently it was sorted out. The habitat of this little brittle-star is, like that of several other species of the genus, in the crannies and cavities of colonial organisms on the bottom in shallow water, and its secretive habits are characteristic of most of the species of Ophiactis. The specimens from Station 45 range from less than 2 mm. across the disk to about 5 mm., and the identification of the smaller ones is, of course, not beyond question. All but one are variegated with light and darker shades of greyish or brownish green. The one exception is obviously artificially stained with a purplish red ; possibly it was preserved originally with a red-purple comatulid.

Remarks.—It is most interesting to find this characteristic South African brittle-star on the South Arabian coast, especially as it was not taken in the Zanzibar area. Probably it occurs along the whole western coast of the Indian Ocean, wherever local conditions are suitable.

Ophiactis plana Lyman.

Ophiactis plana Lyman, 1869, p. 330. Mortensen, 1933*a*, p. 346, fig. 57.

Localities :

Station 24 ; Gulf of Aden ; 73–200 metres. Five specimens.
Station MB I*b* ; Red Sea ; 29 metres. Three specimens.
Station MB I*d* ; Red Sea ; 26 metres. Eight specimens.
Station ? ; One specimen.

Range.—Widely distributed in warmer seas around the world from shallow water to great depths (over 2000 metres).

Notes.—The " Mabahiss " specimens are all small, less than 2 mm. across the disk,

with 6 arms and, with one or two exceptions, show evidence of recent division. The colour shows some diversity, for while all are more or less variegated, those from Station 24 and MB I*b* are light-coloured with a greenish tint, the one from an unknown station is much darker, and those from Station MB I*d* have a distinctly reddish tint.

Remarks.—This material throws little light on the perplexing questions concerning this species which has been described under several different names. Mortensen (1933*a*, p. 346) after study of South African material concludes that " on the whole, it does seem that *O. plana* is a cosmopolitan species like *Ophiactis Savignyi* ". I quite agree with this conclusion, and I believe *O. parva* Mortensen from the Suez Canal is a synonym of *plana*, but without having a specimen of *parva* to compare with the present lot from the Red Sea and Gulf of Aden, I hesitate to assert it.

Ophiactis savignyi.

Ophiolepis savignyi Müller and Troschel, 1842, p. 95.
Ophiactis savignyi Ljungman, 1867, p. 323.
Ophiactis reinhardtii Lütken, 1859, p. 161 ; pl. 3, figs. 7*a*, *b*.

Localities :

Station 133 ; Zanzibar area ; 220 metres. One specimen.

Station MB I*b*, *c*, *d* ; Red Sea ; 26–29 metres. Eighteen specimens.

Range.—Cosmopolitan in all warm seas, from low-water mark to about 100 metres.

Notes.—The specimens at hand are all young and most of them are 6-rayed, and show evidence of recent division. One of the larger specimens (2·5 mm. across disk) is of interest, as it has but 5 rays, and 2 of the arms are much smaller than the other 3, demonstrating the origin of a 5-armed adult by schizogony. Mortensen (1933*b*, p. 447) says he has never seen such a specimen.

Remarks.—There is nothing notable about the occurrence of *savignyi* in either the Zanzibar area or the Red Sea, but it is of interest to note that it and *O. plana* occurred at the same station.

Ophiactis hexacantha* sp. nov. (Text-figs. 32 and 33.)

Localities :

Station 164 ; Maldive area ; 183 metres. One specimen.

Station MB I*b* ; Red Sea ; 29 metres. One specimen.

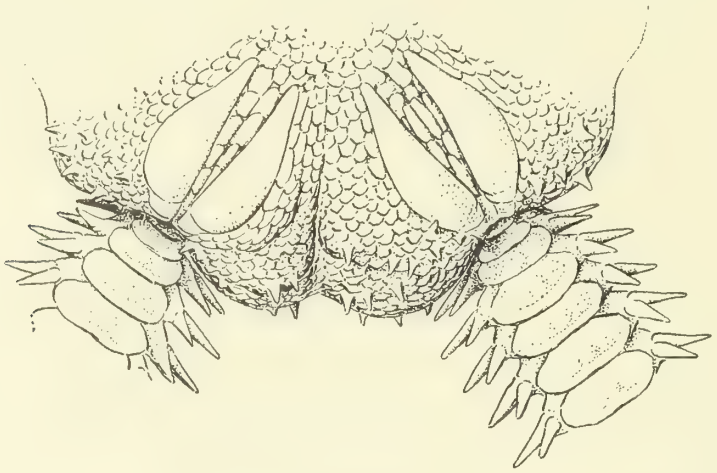
Description.—Disk 6 mm. in diameter, rounded decagonal, with concave radial, and notched interradial sides. Arms 5, not very stout apparently, but all are broken, and of only one is enough left to yield any data. Disk covered with thin, ill-defined scales and large radial shields ; many interradial plates near disk margin bear low, rather slender, but not very acute spinelets, but these are lacking on the disk elsewhere. Radial shields notably large, 1·75 mm. long by ·60 mm. wide just distal to middle ; inner margins straight, in contact at distal tip, but divergent and well separated within ; outer margins convex. Upper arm-plates elliptical, with rounded lateral margins, about three times as wide as long, very broadly in contact.

Interbrachial areas below covered by rather large, thin, overlapping scales, a few of which carry spinelets. First under arm-plate small, nearly square with rounded corners ;

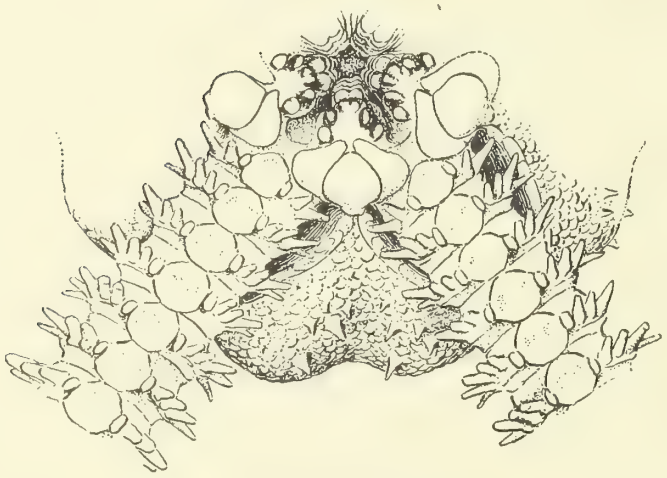
* ἕξ = six + ἄκανθα = spine, in reference to the numerous arm-spines.

succeeding plates much larger, longer than wide with rounded corners and slightly concave lateral margins ; beginning with the fourth, the plates are as wide as long, or even a little wider, the distal margin is quite convex and longer than the proximal, which is nearly straight ; the lateral margins are only a trifle concave, and all corners are much rounded ; the surface of the plate is not smooth and flat, but is depressed on each side, so that the midline and lateral margins, and especially the distal margin, appear to be thickened.

TEXT-FIG. 32.



TEXT-FIG. 33.



TEXT-FIGS. 32, 33.—*Ophiactis hexacantha* sp. nov. FIG. 32.—Dorsal view of part of disk and two arm-bases. × 16. FIG. 33.—Oral view of same. × 16.

Side arm-plates rather small, not meeting either above or below ; each carries a series of 6 or even 7 spines, at right angles to the arm ; lowest spine shortest, thick, somewhat flattened and rounded at tip, so it resembles the closely adjoining tentacle-scale, but is larger ; next spine similar, but larger ; the next is narrower, thicker, a little longer and more pointed ; the fourth is definitely more spine-like, longer and more pointed ; the fifth is longest, but not quite equal to width of arm, somewhat thorny (under considerable magnification) near tip, which is truncate, with a hyaline tooth on each side ; sixth (usually uppermost) spine noticeably shorter than fifth, more flattened and more nearly pointed ; when present the seventh spine is like the sixth, but considerably smaller. Tentacle-scale

single, large, flat, but thick, rounded, notably like the lowest arm-spine, but smaller. Oral shields small, wider than long, rounded diamond-shape, but outlines not very distinct ; madreporite definitely largest. Adoral plates relatively large, meeting within ; those associated with madreporite are elongated and much narrower within than at the radial end ; the others are about equally wide at the two ends ; the radial ends abut on the first under arm-plate. Oral papillæ, 2 on each side, small flat and rounded at tip ; usually the inner is narrower and smaller than the outer, but in one case it is distinctly the larger. Teeth wide, with slightly irregular or notched margin ; lowest (infradental papilla) narrower and smaller than the true teeth. Colour (dry) above very pale brown ; distal tips of radial shields and the spinelets nearly white, as is the oral surface.

Remarks.—The single adult specimen from Station 164 is in such poor condition it is unfortunate to have to make it the type of a new species in so perplexing a genus, but the large radial shields, thin disk-scales, paired oral papillæ and peculiar under arm-plates and lower arm-spines are very definite distinguishing marks. The specimen from the Red Sea is very small, not quite 1·5 mm. across the disk, with arms about 10 mm. long. It was found with *plana*, *savignyi* and *versicolor* and was first considered a young *plana*, but more critical study revealed the pairs of distal, oral papillæ, the thin disk covering and large radial shields, and 5 arm-spines on the basal arm-segments with the lowest ones like the big tentacle-scales. There seems no doubt therefore that the specimen must be considered a young individual of *hexacantha*.

Ophiactis spinulifera* sp. nov. (Text-figs. 34 and 35.)

Localities :

Station 139 ; Maldive area ; 57 metres. One specimen.

Station 144 ; Maldive area ; 31 metres. Two specimens.

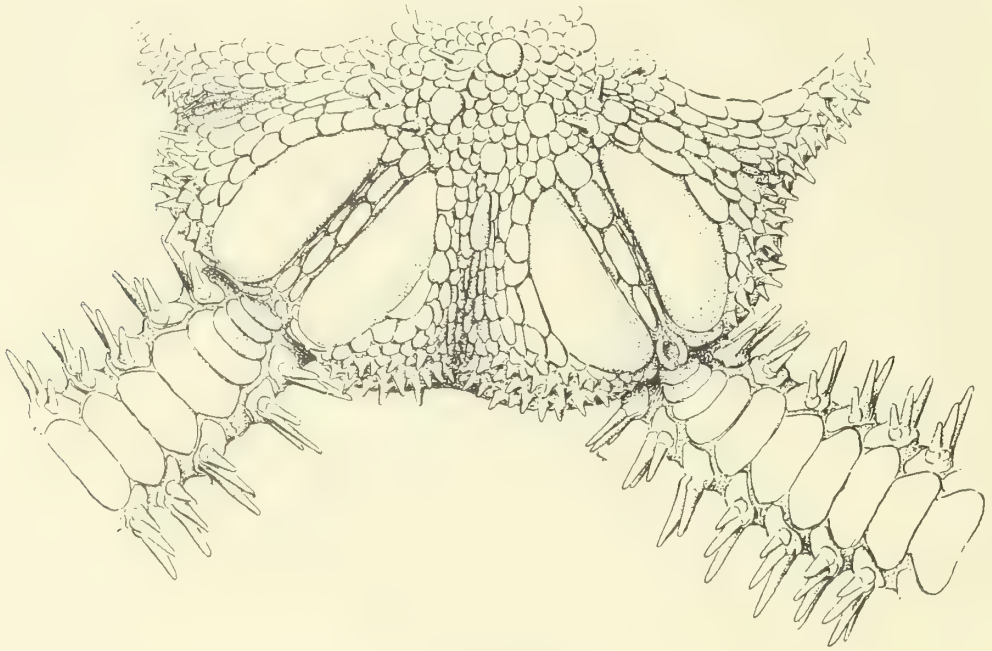
Description.—Disk 6 mm. in diameter, rounded pentagonal with interradial notches. Arms 5, moderately stout and very long ; all are broken, but of one, 50 mm. is still present, and it undoubtedly exceeded 60 mm. in life. Disk covered with a coat of thick, rather coarse scales of varied form, more or less overlapping, a very few of which bear spinelets of moderate size ; on the interradial margins the scales become very small and nearly all bear relatively stout but small, acute spinelets. Radial shields very large, nearly 2 mm. long and a millimetre wide distal to middle ; inner margins straight and diverging from the distal end where they are nearly but not quite in contact ; outer margins curved on the proximal half and distally very convex. Upper arm-plates broadly elliptical with rounded lateral margins, about 2·5–3 times as wide as long, very fully in contact.

Interbrachial areas below so densely covered with spinules that the scales are visible only along the genital slits. First under arm-plate nearly triangular, wider than long, separated from second by the adoral shields. Succeeding plates wider than long, more or less oblong with rounded corners ; at first they are fully in contact, but distally this is less marked, the amount of contact depending on the flexure of the arm. Side arm-plates low and rather small, but each bears 6 or 7 conspicuously projecting spines ; the lowest is shortest and smallest, somewhat club-shaped, not at all like the tentacle-scale ; the next two or three are successively longer and about as stout, the fourth being the longest and stoutest of all ; above it is a much more slender and acute spine, not quite as long ; the

* *spinuliferus* = bearing minute spines, in reference to the character of the interbrachial areas below.

sixth is similar, but shorter, and the seventh, if present, is still shorter. Tentacle-scale single, large, rounded and scale-like, not at all like the lowest arm-spine.

TEXT-FIG. 34.



TEXT-FIG. 35.

TEXT-FIGS. 34, 35.—*Ophiactis spinulifera* sp. nov. FIG. 34.—Dorsal view of part of disk and bases of 2 arms. × 15. FIG. 35.—Oral view of same. × 15.

Oral shields large, somewhat trefoil-shaped (madreporite largest, broadly oval without notches) wider than long; distal side slightly prolonged to join the interbrachial area. Adoral plates small, more or less triangular, not meeting within but lying at the sides of the oral shield; the outer distal corner extends in between the first and second arm-plate, separating them, but not quite reaching its fellow in the midline. Oral papilla single,

large, thick and rounded, but higher than wide, located on the oral plate and not on the adoral. Teeth wide but short, the lowest (infradental papilla) the smallest. Colour (dry) very light, nearly a cream-white, with dusky markings on the upper arm-plates ; these tend to form a broad but ill-defined band on the upper side of the arm.

Remarks.—This is one of the best-defined species in the genus, and quite unlike any previously described. The paratypes are a little smaller than the one described, but differ from it in no important particular. The dusky markings on the upper side of the arms are not evident however. The long arms, big radial shields, large oral papillæ located at middle of jaw and the spiniferous interbrachial areas are distinctive characters. Although the arm-spines are as numerous as in *hexacantha*, their size and form are very different.

Ophiactis versicolor* sp. nov. (Text-fig. 36.)

Locality.—Station MB I*b* ; Red Sea ; 29 metres. Four specimens.

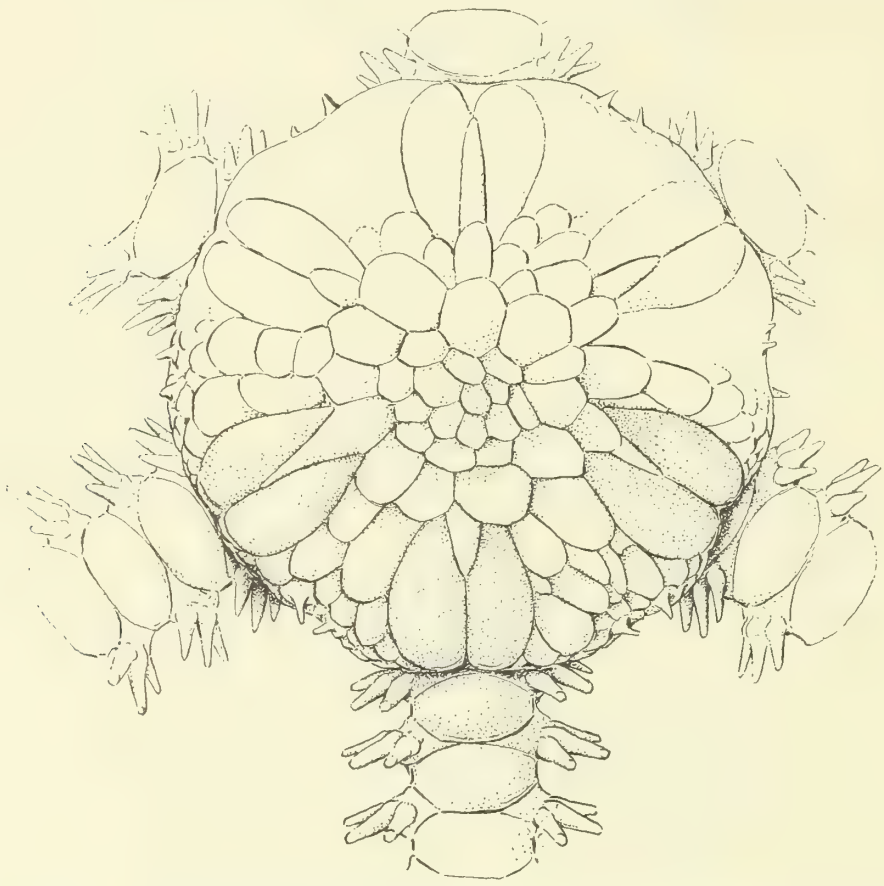
Description.—Disk 3 mm. in diameter, flat and nearly circular. Arms 6, about 10 mm. long, relatively stout, attenuate only near tip. Disk covered by relatively large plates and radial shields ; the plates are largest near centre of disk and become very small at interradial disk margins ; spinules are present only on these minute marginal plates. Radial shields nearly ·75 mm. long, about half that in width, in contact distally, but diverging from that point and well separated proximally ; convex on outer side, straight on inner. Upper arm-plates much wider than long, widest distal to middle, narrowest at proximal margin, which is in full contact with previous plate ; lateral margins, with rounded angles just distal to middle where plate is widest, proximal to which the margin is a little oblique but straight.

Interbrachial areas below covered with small scales, many of which carry minute spinules. Under arm-plates nearly square, with rounded angles, fully in contact ; distal margin only a trifle longer than proximal, lateral margins very slightly concave ; first under arm-plate small, triangular or possibly pentagonal, separated from second plate by the adoral plates, although the latter do not quite meet. Side arm-plates small, carrying but 4 short, stout, blunt spines in a bristling vertical series ; lowest is shortest and stoutest, the next is a little longer, the third is longest, but little exceeds the arm-segment and does not nearly equal arm-width ; the fourth and uppermost is about as long as the second, but not so stout. Tentacle-scale single, large, flat, rounded, rather longer than wide.

Oral shields rounded triangular or somewhat diamond-shaped, wider than long ; madreporite largest and least angular. Adoral plates rather large, more or less triangular with rounded angles, not meeting within or without, but tending to keep the first and second under arm-plates separated. Oral papilla single, flat, rounded and scale-like, rather longer than wide, situated on the inner end of the adoral plate. Teeth not very wide, but stout. Jaw very short, so that the lowest tooth (infradental papilla) is nearly between the two oral papillæ and seems almost to rest on the inner tip of the oral shield, as though there were no oral plates. Colour of disk of dry specimen, mixed light and dark green of an olive tint with an irregular blotch of dull red at centre ; upper arm-plates prettily variegated with green, red and dirty whitish ; on some plates the green greatly predominates, and on others the red, so that the arm is irregularly and indefinitely banded with green and red ; arm-spines and oral surface dingy white or pale greyish brown.

* *versicolor* = variegated, in reference to the diversified coloration.

Remarks.—This prettily-coloured species is distinguished from the other species of Ophiactis in the collection by the rather coarse disk covering and relatively large but narrow radial shields, the short jaws, the few short, thick arm-spines and the squarish under arm-plates. In the type and one paratype (2 mm. across disk) the green and red coloration is distinctive, but in the two other paratypes, which are very young, it is not sufficiently developed. The disk scaling and upper arm-plates prevent confusion with *plana* however. It is remarkable that in nearly all structural details this species is very close to the West Indian *mülleri* (*cyanosticta* H. L. Clark, see Mortensen, 1933*b*, p. 447),



Text-fig. 36.—*Ophiactis versicolor* sp. nov. Dorsal view of disk and arm-bases. × 20.

but the arm-spines are shorter and more stumpy and the under arm-plates more nearly square. The coloration is, of course, totally different.

Ophiodaphne materna Koehler.

Ophiodaphne materna Köehler, 1930, p. 129 ; pl. 16, figs. 3–8.

Locality.—Station MB IIc ; Arabian coast ; 29 metres. One specimen.

Range.—Kei Islands and North-western Australia, 10–245 metres.

Notes.—This single specimen is little more than a millimetre across the disk, but it is so well preserved there is no doubt of its generic position. After comparison with the Ophiodaphnes at hand, it seems best to consider it a young female of *materna*, though it is

not at all unlikely sufficient material would show that the Arabian species is quite distinct. The colour of the " Mabahiss " specimen is a very pale grey, quite different from the yellowish-brown shade of the East Indian species.

Remarks.—Mortensen (1933, p. 183) has shown that the small individual carried over her mouth by the adult Ophiodaphne is not her young as supposed by Koehler, but is really a complementary male. The specimen which the Museum of Comparative Zoölogy received most generously from Dr. Mortensen carries such a male ; it is only a little smaller than the " Mabahiss " specimen. But it is interesting to note that the disk covering of the Arabian ophiuran is not much like this male, but is much more like that of the adult female. It seems probable therefore that this specimen is a young female, and not a male that has been torn loose from his partner. The extension of range of Ophiodaphne by the discovery of this minute individual on the Arabian coast is very extraordinary, and emphasizes again our ignorance of the actual distribution of what we call the Indo-Pacific fauna.

Family **OPHIOTRICHIDÆ.**

Ophiothrix demessa Lyman.

Ophiothrix demessa Lyman, 1861, p. 82. Koehler, 1905, pl. 9, figs. 5 and 6.

Localities :

Station 27 ; Gulf of Aden ; 37–91 metres. One specimen.

Station MB I*c* ; Red Sea ; 26 metres. One specimen.

Range.—Red Sea and Madagascar to Hawaiian Islands, in shallow water.

Notes.—Both of these specimens are the pink form of this well-marked species. The disk is nearly white in the dry specimens, while the arms are banded with pink and light but dusky purple. The specimen from Station 27 is 10 mm. across the disk ; the other is only half as large.

Remarks.—Koehler (1907, p. 332) has already recorded this species from the Red Sea, so its presence in the " Mabahiss " collection is not surprising.

Ophiothrix otiosa Koehler.

Ophiothrix otiosa Koehler, 1898, p. 99 ; pl. 3, figs. 17–19.

Localities :

Station 10 ; Red Sea ; 55 metres. Three specimens.

Station 45 ; South Arabian coast ; 38 metres. One specimen.

Station MB I*b* ; Red Sea ; 29 metres. Twenty-three specimens.

Station MB I*d* ; Red Sea ; 26 metres. Twenty specimens.

Range.—Malabar coast, 65 metres.

Notes.—The great majority of these specimens are very small (1–3 mm. across disk) and would be quite unidentifiable were it not for their association with the larger specimens (5–6 mm.), several of which answer well to Koehler's description. There is great diversity in colour, as usual in Ophiothrix, but a number are nearly " uniformément rosee ", as described. Several, however, notably the one from Station 45, are very light, a pale greyish purple with the spines white. Many specimens, but not all, have a distinct narrow

longitudinal light stripe on the upper side of the arm ; in the light-coloured individuals this is bounded by a very narrow purplish line. Since Koehler had only two specimens it is not strange he failed to note any diversity of colour. In one other detail these specimens show a diversity not evident in Koehler's ; the surface of the disk carries long, very slender spines among the thorny cylinders which cover it densely ; in one large specimen there are only 2 or 3 of these spines, but in other cases they are conspicuously numerous. Probably they are sometimes entirely wanting as they seem to have been in Koehler's types.

Remarks.—It is not surprising to find this species, originally taken on the Malabar coast, common in the Red Sea, but it seems very probable that it is really identical with *O. savignyi* M. & T. to which Mortensen (1926, p. 121) unceremoniously assigns Koehler's species *beata* (1907, p. 330). Oddly enough Koehler makes no reference to *otiosa* in his account of *beata*, and yet a comparison of his descriptions and figures fails to reveal any other notable difference than the presence of the slender disk-spines in *beata*, and these apparently may occur in *otiosa*. There is a curious slip of the pen in the original description of the latter (line 4 from bottom of p. 99), where Koehler has written " boucliers radiaux " for " boucliers buccaux ".

Ophiothrix amphibola* sp. nov.

Locality.—Station 106 ; Zanzibar area ; 183–194 metres. Two specimens.

Description.—Disk 4 mm. in diameter, rounded pentagonal, flat. Arms 5, short, none is entire but they did not exceed 18 mm. in life. Disk covered by large radial shields and numerous very small scales ; many scales carry low trifid stumps, which are not numerous enough to form a real covering to the disk ; the 3 terminal thorns are not very long, about equal to the short stump itself ; here and there among the stumps is a slender spinelet. Radial shields very large and bare ; there are stumps along the margin, and rarely one or two on the surface. Upper arm-plates diamond-shaped with rounded angles, at first wider than long, but becoming longer than wide ; distal angle considerably swollen, proximal flat and truncate ; the plates are barely in contact on basal half of arm, but become separated distally.

Oral surface and mouth parts as usual in the genus, not distinctive. Under arm-plates squarish, wider than long, with rounded corners, fully in contact on base of arm ; distally the proximal end becomes a little narrower and the plates much longer than wide, remaining fully in contact. Arm-spines few, short, relatively thick, blunt and coarsely thorny ; there are 4 or 5 in each series, with the upper one or two longest, but not exceeding the arm-width. Tentacle-scale insignificant. Oral shields much wider than long, with small adorals lying on their inner side, as is usual in Ophiothrix, not in any way distinctive. Colour (dry) pale grey above, white below ; arm-spines not very hyaline, white ; distal tips of upper arm-plates more or less white, not conspicuously so, but a characteristic mark.

Remarks.—The paratype is a little smaller and the disk is yellowish rather than greyish, but the specimens are otherwise very similar. I have sought in vain for a previously described species to which I might refer these insignificant brittle-stars, and I have therefore given them a name, but it has not seemed necessary to give figures, for there isn't a single significant character to be shown. Koehler (1922, pl. 52, figs. 8–10)

* *ἀμφίβολος* = *doubtful*, in reference to the dubious validity of the species.

gives figures of an Ophiothrix which in the explanation of the plate he calls *miles*, but I have been unable to find in index, table of contents, or anywhere else in the text any references to these figures or to the species *miles*, which he described in 1905 from an unknown " Siboga " station (1905, p. 90). The figures of the disk would do fairly well for *amphibola*, but the arm-spines (fig. 9) appear to be quite unlike the Zanzibar species ; it is unlikely the two are identical.

Placophiothrix aristulata (Lyman).

Ophiothrix aristulata Lyman, 1879, p. 50 ; pl. 15, figs. 421–424.
Placophiothrix aristulata H. L. Clark, 1938, p. 310.

Localities :

Station 24 ; Gulf of Aden ; 73–200 metres. Three specimens.
Station 25 ; Gulf of Aden ; 620 metres. One specimen.
Station 43 ; South Arabian coast ; 83–100 metres. Two specimens.
Station 154 ; Maldive area ; 457 metres. Two specimens.
Station 157 ; Maldive area ; 229 metres. One specimen.

Range.—Cape of Good Hope to Philippine Islands and south to Tasmania, 70–530 metres.

Notes.—The specimens from Station 154 are beautiful examples of this handsome species, measuring 14 and 17 mm. across the disk. The colour is as usual, the disk white, the arms pinkish (spines white) with a conspicuous longitudinal white stripe along the middle of the upper side ; oral surface white. The spines on the disk are relatively short (1–3 mm.) and numerous, but are acicular as usual. The specimen from Station 25 is only 7 mm. across the disk and the pink colour has a violet tinge ; the whole disk is faintly tinted with it. In other details this individual is typical. But the specimen from Station 157 is of somewhat dubious authenticity, for it is only 4·5 mm. across the disk, and in such poor condition that satisfactory identification is impossible. A note accompanying it states that it was taken from branches of an " alcyonarian of Nicella type ". The specimens from Stations 24 and 43 are even smaller, only 2–3·5 mm. in disk diameter, and lack any distinctive colour, but they may, I feel very sure, be properly considered very young individuals of *aristulata*.

Remarks.—This handsome brittle-star was first found at the Cape of Good Hope by the " Challenger ", but has since been taken by the " Investigator ", the " Siboga ", the " Albatross ", and by Dr. Mortensen in the north and eastern parts of the Indian Ocean. Its range has also been extended southward by the " Endeavour " to Tasmania, and by the " Terra Nova " to New Zealand. It is quite natural therefore that it should have been found by the " Mabahiss " in the Maldive area, and even in the Gulf of Aden.

Placophiothrix infirma (Koehler).

Ophiothrix infirma Koehler, 1905, p. 89 ; 1922, p. 241 ; pl. 48, figs. 5–7.

Locality.—Station 24 ; Gulf of Aden ; 73–200 metres. One specimen.

Range.—Sulu Archipelago to Flores and Kei Islands, 50–90 metres.

Notes.—The present specimen is 6 mm. across the disk and the arms are 35–40 mm. in length. The disk (dry) is a greyish white with pink markings at the tip of the big radial

shields. The arms are white with a pink tinge which is very marked on the spines ; there is no continuous white line bordered with purple as described by Koehler, but the distal half of each upper arm-plate is quite white and on many plates there are dark lines and markings which suggest the last remnants of a dark-bordered white line. On the lower surface of the arm is a definite white line, as shown by Koehler, but on a few plates its boundaries are hazy, and on many it is constricted by a dull brownish pink area on each side.

Remarks.—In spite of the differences in the coloration of the arms I have no doubt of the identity of the specimen. Whether it should be placed in Placophiothrix is more open to question, but the large bare radial shields warrant it, and it is better there than in Ophiothrix itself. The occurrence of *infirma* in the Gulf of Aden is a notable extension of its range.

Placophiothrix proteus (Koehler).

Ophiothrix proteus Koehler, 1905, p. 100 ; 1922, pl. 36, figs. 3 and 4.

Locality.—Station MB II ; Arabian coast ; 11–29 metres. Thirty-four specimens.

Range.—New Caledonia and the East Indies to Ceylon, 35–92 metres.

Notes.—This is a very fine series, ranging from 2·5 to 10 mm. in disk diameter. None shows a trace of red or purple in the coloration, but all have the green and white markings shown by the specimens described by Koehler from " Siboga " Stations 64 and 179. The " Mabahiss " specimens have been compared with a paratype from " Siboga " Station 260.

Remarks.—This is a well-marked and handsome species whose occurrence on the Arabian coast is of no little interest. The green and white coloration is so distinctive one can but wonder whether two distinct species are not confused under the name *proteus*.

Placophiothrix purpurea (von Martens).

Ophiothrix purpurea von Martens, 1867, p. 346. Döderlein, 1896, pl. 17, figs. 23, 23*a*.
Ophiothrix lepida de Loriol, 1893, p. 38 ; pl. 25, figs. 1–1*f*.

Localities :—

Station 10 ; Red Sea ; 55 metres. Four specimens.
Station 24 ; Gulf of Aden ; 73–200 metres. Thirty-two specimens.
Station 27 ; Gulf of Aden ; 37–91 metres. Four specimens.
Station 54 ; South Arabian coast ; 1046 metres. One specimen.
Station 164 ; Maldive area ; 183 metres. Two specimens.
Station MB I*a* ; Red Sea ; 29 metres. Four specimens.
Station MB I*d* ; Red Sea ; 26 metres. Three specimens.

Range.—Philippine Islands and East Indies, south to New Caledonia and the Kei Islands, west to Maldive Islands, Mauritius and Madagascar, 7–400 metres.

Notes.—Most of these 50 specimens are young, ranging from 2 to 5 mm. in disk diameter, and of little significance, but the series from Station 24 is of great value, as many of the specimens are adults (5–9 mm. across disk), and show great diversity in the form of the radial shields and in details of coloration. The specimen from Station 54 shows no peculiarities of either structure or colour associated with the great depth at which it

was taken. Those from Station 164 are also from a greater depth than the usual range of the species ; although they are in poor condition, they are typical *purpurea*. The diversity of colour among the 50 specimens is considerable, but it is more of degree than of kind. The disk ranges from a greenish white, with a rosy tint on the distal ends of the radial shields, to a pale grey much marked and variegated with dull crimson or more commonly reddish purple. In nearly all specimens a reddish purple line follows the outline of each radial shield ; often this line is incomplete or wanting on the inner margin of each shield ; in other cases, additional lines cross the shields irregularly, and in the darkest specimens the whole disk is conspicuously variegated with purplish red and greyish white. The upper arm-spines, or at least their upper sides, are purplish red, dull rose or pink, but the lower spines are colourless. Without exception there is a dark longitudinal line along the middle of the upper arm-plates ; in no case is this broken or discontinuous, as it is in some East Indian specimens of *purpurea*. The colour of the line ranges from crimson to deep purple, which is sometimes so dark it might be called black. In some cases there is a more or less definite white line on each side of the dark one, and in two or three specimens a very narrow coloured line limits the outer side of this light area. The oral surface is cream-white, but there is some sort of a longitudinal line along the middle of the under arm-plates in every specimen. This line is usually rusty brown, but it may be darker, approaching brown-purplish ; it is usually well-defined on the basal under arm-plates, but is less so distally. In some specimens it is very faint, and occasionally its margins are so much darker than its centre that the appearance is that of two very narrow parallel lines.

Remarks.—This series of specimens leaves no room for doubt that Koehler (1898, p. 103 ; 1922, p. 247) is mistaken in attempting to maintain *lepida* as a valid species distinct from *purpurea*. The photographs which he gives (1922, pls. 36 and 58) as showing the distinctive characters of each species can be matched from the material from " Mabahiss " Station 24, and there are sufficiently numerous and satisfactory intergrades to compel us to call them all one species. The difference in the tentacle-scales which Koehler stresses I have not been able to detect in the material available to me.

Placophiothrix encarsia* sp. nov. (Text-figs. 37 and 38.)

Locality.—Station unknown.

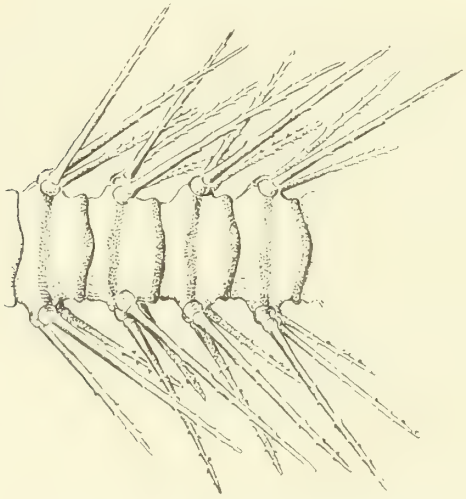
Description.—Disk 3 mm. in diameter ; arms 5, about 12–15 mm. long. Disk covered by the large radial shields, a large central plate (indication of immaturity) and an indefinite number of small plates, but the outlines of all are more or less completely obscured by a skin or membrane, which is quite possibly an artefact. Half a dozen of the central plates each carry a long, acicular, but not thorny spine. The interradial plates at disk-margin carry large thorny stumps. Radial shields large, but the outlines are obscure ; apparently each shield is long triangular, reaching two-thirds of the way to centre of disk with the inner margin the base of the triangle, whose height is about one-half its length ; all the angles are rounded, especially the distal one ; the two shields of each pair seem to be quite separated by 2 or 3 long, narrow scales. Upper arm-plates notably large, but even with the use of benzol, their exact form cannot be made out ; apparently they cover the entire upper surface of the arm, but are a little narrower proximally than distally.

* ἐγκάρσια = *transverse*, in reference to the notable coloration of the arms.

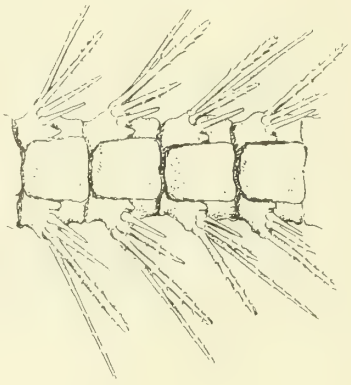
Oral surface as usual in Placophiothrix, with oral shields much wider than long, but the outlines of the plates are so obscured by the membranous covering, one cannot be sure of the exact details. Under arm-plates very large, about as wide as long, with corners rounded, nearly covering the lower surface of arm, but apparently not in contact with each other. Side arm-plates very small; each plate carries 4 or 5 slender spines, the uppermost longest, the lowest very small; the uppermost is as long as 3–4 arm-segments, acicular and scarcely thorny; those below are shorter, blunter, a little stouter and more thorny. Tentacle-scale triangular, very small, but relatively rather large.

Colour white, with each radial shield outlined in red-purple, and each arm segment crossed by two narrow transverse lines of the same shade; one of these lines runs from the base of an upper arm-spine to its fellow on the opposite side, and the red-purple colour extends along the upper side of these spines; the other line encircles the arm passing between the under arm-plates.

Text-fig. 37.



Text-fig. 38.



Text-figs. 37, 38.—*Placophiothrix encarsia* sp. nov. Fig. 37.—Upper surface of four arm-segments to show the transverse striping. × 15. Fig. 38.—Oral surface of same. × 15.

Remarks.—The specimen upon which this new species is based is undoubtedly young, but its extraordinary arm-plates and conspicuous coloration are specific characters which set it apart sharply from its congeners. It is unquestionably a Placophiothrix, allied to *proteus* and *purpurea*, but it cannot be confused with either of them. It is a great pity that there should be no locality known for so remarkably well-characterized a species. The only label with it reads "Op. 11", and in the list of ophiurans, at No. 11 we read "no label".

Placophiothrix phrixa* sp. nov. (Text-figs. 39 and 40.)

Localities:

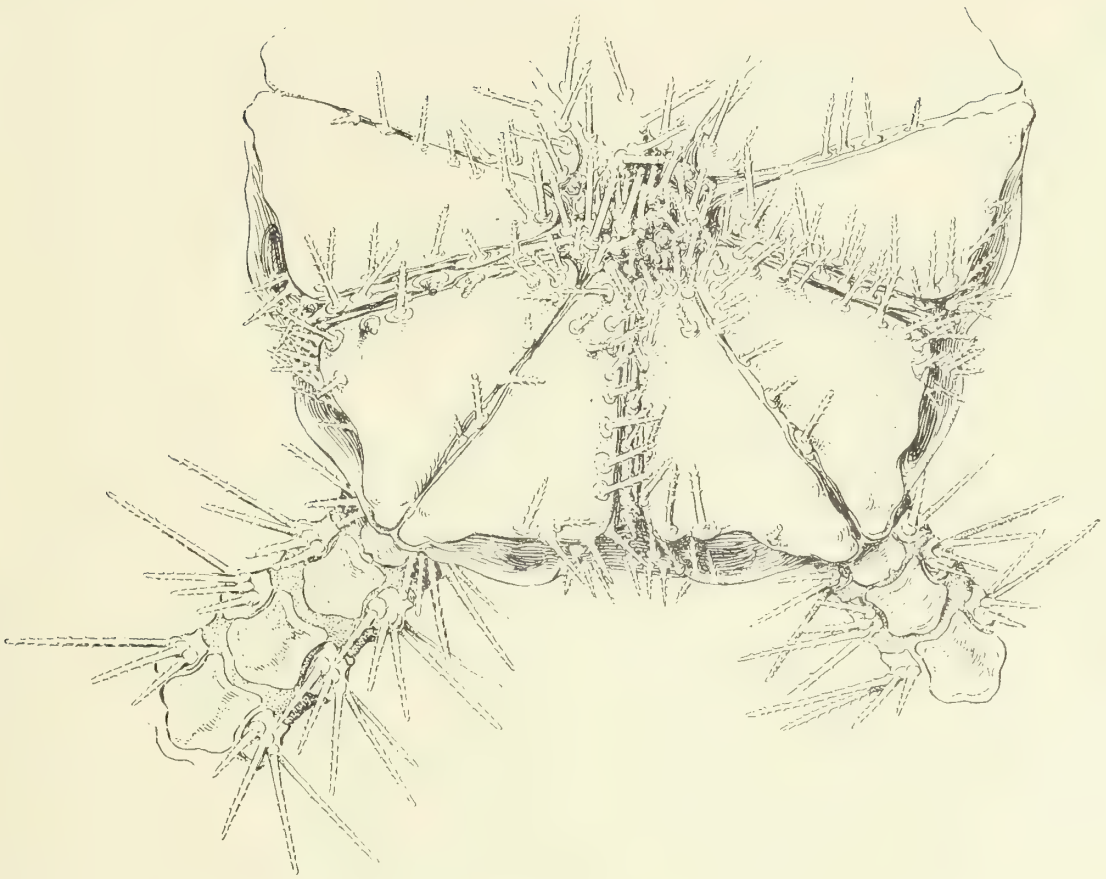
Station 27; Gulf of Aden; 37–91 metres. Four specimens.

Station 45; South Arabian coast; 38 metres. Ten specimens.

Description.—Disk 7 mm. across; arms 5, all broken, but to judge from all the specimens, they were probably not less than 50 mm. long in life. Disk almost wholly

* φριξός = *bristling*, in reference to the numerous spines on the disk and arms.

TEXT-FIG. 39.



TEXT-FIG. 40.

TEXT-FIGS. 39, 40.—*Placophiothrix phrixa* sp. nov. FIG. 39.—Dorsal view of most of disk and two arm-bases. × 15. FIG. 40.—Oral view of same. × 15.

covered by the radial shields; centre of disk, narrow interbrachial areas and very narrow radial areas between the two shields of a pair, covered by a thin skin which bears very small and not at all crowded plates, most of which carry, each, a long acicular, but more or less thorny spine ; similar spines occur in numbers on the interradial and distal margins of the radial shields. Interradial margins of disk with many similar but somewhat smaller spines. Upper arm-plates pentagonal, about as wide as long ; all angles rounded ; proximal margin concave or distinctly notched ; distal angle with a conspicuous knob, the thickest and most elevated part of a median keel or ridge which is scarcely evident at proximal end of plate ; plates not in contact with each other, but more or less noticeably separated by thin, naked skin.

Interbrachial areas below covered by thin skin, which is nearly naked, but carries near the disk margin some very small plates, each of which, as a rule, bears a tiny spinelet ; genital plate and genital scale very conspicuous. Under arm-plates slightly separated from each other by naked skin, more or less hexagonal (or pentagonal) with rounded angles, apparently longer than wide, but the difference is slight ; centre of plate thinner than margins and a little depressed, giving the appearance of a longitudinal stripe along middle of lower surface of arm, but there is no pigment involved. Side arm-plates narrow, well separated from each other by naked skin ; each plate carries 5 (near base of arm 6 or even 7) arm-spines, of which the uppermost are very long and slender, nearly equalling 3 arm-segments ; these spines are not very thorny, but are not perfectly smooth, and they are not noticeably sharp-pointed ; the spines decrease in length ventrally very rapidly, and the lowest is minute. Tentacle-scale generally wanting, but may be present, though very minute, on the basal pores of the arm.

Oral shields elliptical or rounded diamond-shape, twice as wide as long, or even wider. Adoral plates exceedingly narrow, about four times as long as wide, practically, but not quite, meeting within. Oral papillæ wanting of course, and teeth as usual in the family.

Colour (dry) of all calcareous parts white ; of the naked skin, brown of some shade, darkest on interbrachial areas below and lightest on sides of arms distally. Every third or fourth upper arm-plate has the proximal half (rarely it is the distal end) faintly outlined in red-purple and lightly tinted with that shade. In some of the very young specimens this red-purple tint is so marked that the arms are distinctly banded and even on the disk-especially the radial shields, a pink coloration is perfectly evident. In some of the young, however, there is no more pigment than in the adults. In one specimen it is distinctly violet, with no hint of red.

Remarks.—This is a very satisfactory series of specimens, ranging from 2 to 9 mm. in disk diameter. The specimens from Station 27 are all young, but are unmistakable. The huge radial shields, the exceptional amount of uncalcified skin, the numerous disk-spines, and the character of the arm-plates serve to distinguish this species from any of its near relatives.

Ophiotrichoides propinqua (Lyman).

Ophiothrix propinqua Lyman, 1861, p. 83. Koehler, 1922, pl. 38, figs. 1 and 2.

Locality.—Station MB I*b* ; Red Sea ; 29 metres. Two specimens.

Range.—From Zanzibar to the Gilbert Islands, from low-water mark to 54 metres.

Notes.—The smaller specimen (3 mm. across disk) has little red in the coloration, only an occasional upper arm-plate being somewhat reddish ; the disk and most of the upper arm-plates are distinctly dull blue and cream colour. But the larger one (5 mm. across disk) has the disk dull rose-red and cream colour, while the upper arm-plates alternate irregularly between rose and cream colour and dull blue and cream colour. This specimen has more red than any other specimen I have seen.

Remarks.—The occurrence of this species in the Red Sea is not surprising, but its discovery there is an interesting extension of its range.

Macrophiothrix brevipeda H. L. Clark.

Macrophiothrix brevipeda H. L. Clark, 1938, p. 290, fig. 20.

Localities :

Station 45 ; South Arabian coast ; 38 metres. Twenty-eight specimens.

Station 53 ; South Arabian coast ; 13·5 metres. Twenty-six specimens.

Range.—Coast of Natal, 45–90 metres.

Notes.—This is indeed a notable series of this recently described and little known species. The specimens range from 3 to 13 mm. across the disk, and hence show a complete series of growth changes. But there is surprisingly little diversity, for all are definitely blue and white, though the largest has the disk more pale brown, and some of the smaller specimens tend the same way. In all, the white longitudinal stripe of the upper side of the arm is noticeable and that on the under arm-plates is equally well marked. The short arms are a striking characteristic, for they are only 5–6 times the disk diameter, and thus belie the generic name. But the general appearance is so like *longipeda* and its allies that there is no doubt of the generic position.

Remarks.—The discovery of this species, hitherto known only from Natal, off the South Arabian coast, is indeed a notable extension of range, but there is no doubt of the identity of the species, for in the recently published key to Macrophiothrix (H. L. Clark, 1938, p. 280) these specimens run down to *brevipeda* without any difficulty, and comparison with the holotype of that species shows they are identical. The only difference is that the Arabian specimens are definitely blue and white, while the Natal specimens have little indication of blue, except for a hint of it on the upper arm-plates of the holotype. Apparently *brevipeda* is an East African species reaching the southern limit of its range on the coast of Natal, and its northern on the Arabian coast. Further study of Macrophiothrix from East Africa, Mauritius and Madagascar is greatly to be desired.

Ophiothela cærulea H. L. Clark.

Ophiothela cærulea H. L. Clark, 1915, p. 283 ; pl. 14, fig. 1.

Localities :

Station 45 ; South Arabian coast ; 38 metres. Two hundred and eleven specimens.

Station 53 ; South Arabian coast ; 13·5 metres. Twenty-five specimens.

Station MB II*a* ; South Arabian coast ; 11 metres. One specimen.

Station MB II*c* ; South Arabian coast ; 29 metres. Five specimens.

Range.—Known previously only from the holotype, which was taken in the Arabian Gulf in April, 1861.

Notes.—This bewildering array of more than two hundred specimens shows that the holotype was an abnormal or possibly a young individual, for it had 6 arms, and in the present series there are but 2 hexamerous specimens, and these are very young, with the disk but 2 mm. in diameter. Moreover adults of this species attain as much as 7 mm. across the disk and the arms are 4–5 times as much. The coloration is so amazingly varied that no two specimens are exactly alike. Nearly all show more or less blue, so that the name is not inappropriate, but many have more or less red or violet and a few are wholly light brown, greenish and white or cream colour. There is equally great diversity in the armature of the disk; in some individuals the huge radial shields are smooth and unarmed, and only a few low, pointed tubercles are to be found on the disk margin; at the other extreme are those in which the whole disk, radial shields and all, is covered, though not closely, with spinelets, pointed tubercles, granules and even thorny, pointed stumps. This is in no sense a matter of age or size.

Remarks.—This long series of Ophiothelas raises anew the question as to how many of the nine or ten named species are really valid. The anatomical characters of the genus have never been well worked out, and just what features may be valid as specific characters is yet to be shown. But there is, I think, no doubt that the present series represents but one species, and that the one first taken in the Arabian Sea and called *cærulea*.

Order **CHILOPHIURIDA.**

Family **OPHIOCHITONIDÆ.**

Ophiochiton megalaspis* sp. nov. (Text-fig. 41.)

Localities:

? Station 45; South Arabian coast; 38 metres. One specimen.

Station 54; South Arabian coast; 1046 metres. One specimen.

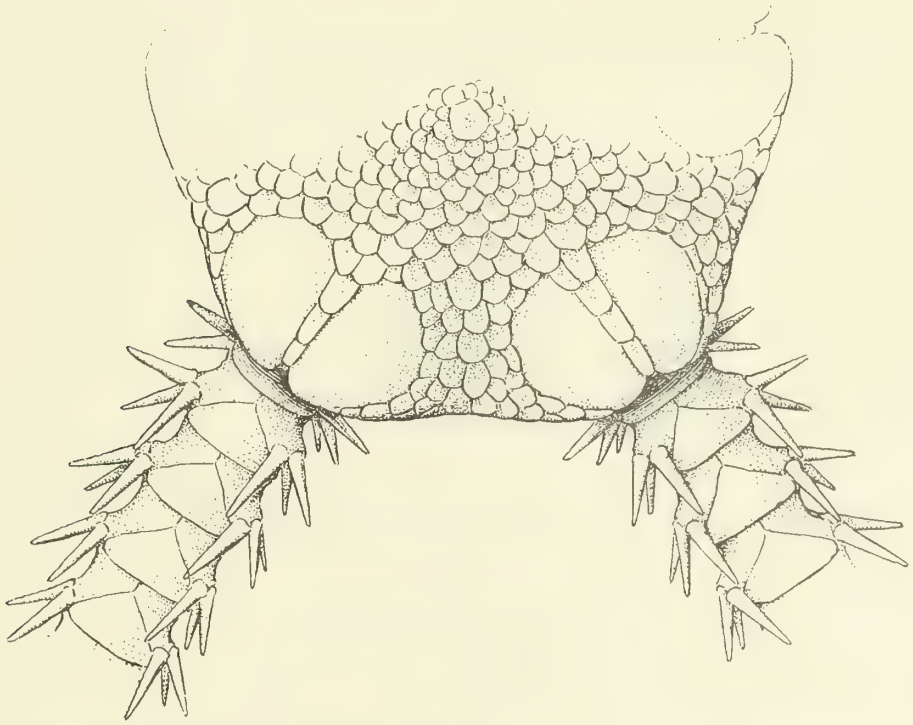
Description.—Disk very flat and thin, rounded pentagonal, 7 mm. in diameter. Arms 5, 30–35 mm. long, rather stout at base, but tapering rapidly to the somewhat attenuate tip. Disk covered with a coat of rather large, flat, more or less circular, but to some extent overlapping scales, and 5 pairs of very large radial shields; in the radial line a single series of elongated scales separates the two shields of a pair, but in each interradius there are about 5 columns of disk-scales overlapping laterally and not elongated. Each radial shield is irregularly pear-shaped, the narrow end distal and distinctly thickened; the shield is about 1·5 mm. long and the width is very nearly the same; the proximal end is somewhat truncate or slightly rounded. Upper arm-plates triangular, much wider than long, slightly swollen, with lateral angles rounded, well separated from each other.

Interbrachial areas below well covered with scales similar to those on the disk. Under arm-plates flat, triangular, at first wider than long, but distally length and breadth are about equal; they are well separated from each other except at the very base of the arm. On some of the proximal plates, the tentacle-pores cut into the lateral margins enough to

* μέγας(μεγαλ) = big + ἀσπίς = shield, in reference to the very large radial shields.

give the plate a pseudo-pentagonal form. Side arm-plates low but thick ; each carries 3 arm-spines rather thick at base and bluntly pointed ; uppermost longest, exceeding the arm-segment ; lowest shortest, about equalling the segment. Tentacle-scales 2, flat and more or less elliptical, about half as long as the under arm-plate ; the outer is wider than the inner and more or less overlaps it.

Oral shields rather small, diamond-shape, much wider than long, all angles slightly rounded and each side a trifle concave ; distal angle wider, more rounded and more projecting than proximal. Adoral plates relatively large, meeting within, narrower there than at outer end, where a lobe separates the oral shield from the side arm-plate. Oral plates large, carrying 4 oral papillæ, which are flat, rounded or bluntly pointed and subequal, or the distalmost is largest. Teeth rather narrow, bluntly pointed or rounded.



Text-fig. 41.—*Ophiochiton megalaspis* sp. nov. Dorsal view of part of disk and two arm-bases. × 12.

Colour (dry) dull, pale greenish grey, becoming nearly white on the distal part of the arms ; each disk scale has the margin a little lighter than the centre.

Remarks.—The holotype is from Station 54. The paratype, which is very similar but smaller, is supposed to be from Station 45. It is rather more than 5 mm. across the disk and the arms are 25 mm. long. It is lighter coloured than the larger specimen, and the disk-scales are not distinctly lighter on the margin. As the genus is normally found in moderately deep water, 125–2150 metres, it seems to me probable that there has been a mistake in transcribing the station number, and that the smaller specimen is really from the same station (54) as the larger. The species is easily distinguished from the other known members of the genus by its very large radial shields, coarse disk-scales and triangular upper and under arm-plates.

Ophionereis australis (H. L. Clark).

Ophiochiton australis H. L. Clark, 1923, p. 345 ; pl. 20, figs. 1, 2.
Ophionereis australis Mortensen, 1933*a*, p. 374.

Locality.—Station 45 ; South Arabian coast ; 38 metres. Three specimens.

Range.—Coast of Natal, 85–200 metres.

Notes.—These specimens range from 5 to 8 mm. across the disk, and the arms were apparently about 7 times as much. They resemble so closely a paratype from Natal that they call for little discussion. They are lighter coloured and show the markings more clearly ; the lower surface of the arms is white, indefinitely but evidently banded with light reddish purple. The upper surface of the arms is also somewhat banded with a dull purplish dusky, and the white on the radial shields is very conspicuous.

Remarks.—As Dr. Mortensen (1933*a*) has pointed out, in my original description of this species I completely overlooked the supplementary plates and yet published a figure showing them ! As Mortensen says, they are developed only on the basal part of the arm in young specimens, and even in adults appear to die out distally. They seem to be more generally present and more easily seen in the Arabian specimens than in those from South Africa. The finding of *australis* on the South Arabian coast in shallow water is indeed a notable extension of its range. Apparently its distribution is like that of *Macrophiothrix brevipeda*.

Ophionereis porrecta Lyman.

Ophionereis porrecta Lyman, 1860, p. 260 ; 1865, p. 147, figs. 14 and 15.

Locality.—Station 164 ; Maldive area ; 183 metres. One specimen.

Range.—Hawaiian Islands to Japan, Northern Australia, Ceylon and the Laccadive Islands, low water to 100 metres.

Notes.—The present specimen is 10 mm. across the disk and the arms, all but one of which are detached, are about 75 mm. long. The colour is light and dark grey with touches of cream colour.

Remarks.—It is not strange that this Ophionereis was taken in the Maldive area, for that is not quite so far to the north-west as the station in the Laccadives where the " Investigator " took it. But it is noteworthy that its bathymetrical range is considerably extended by the " Mabahiss " collection.

Family **OPHIOCOMIDÆ.**

Ophiocoma insularia var. variegata (E. A. Smith).

Ophiocoma variegata E. A. Smith, 1876, p. 39.
Ophiocoma insularia var. *variegata* H. L. Clark, 1938, p. 330.

Locality.—Station 111 ; Zanzibar area ; 73–165 metres. One specimen.

Range.—Widely distributed in the Indo-Pacific region from Zanzibar to the Hawaiian Islands, along shore and in shallow water.

Notes.—This is a very young individual, only 3·5 mm. across the disk, which is pale grey-brown with a few small touches of cream colour, in contrast to the darker purplish grey of the arms ; the oral frame and basal under arm-plates are very pale cream colour.

Remarks.—This little individual is too young to throw any light on the relationship of *variegata* to *insularia*, a matter which still needs clearing up.

Ophiocoma scolopendrina (Lamarck).

Ophiura scolopendrina Lamarck, 1816, p. 544.
Ophiocoma scolopendrina Müller and Troschel, 1842, p. 101. H. L. Clark, 1915 ; pl. 14, figs. 10 and 11.

Localities :

Red Sea ; Zukayer Island, shore collecting. One specimen.
Locality unknown. Nine specimens.
Station 164 ; Maldive area ; 183 metres. One specimen.

Range.—From Arabian Gulf to Mozambique and eastward to the Hawaiian and Paumotu Islands, in shallow water.

Notes.—The specimen from the Red Sea is a fine adult, and it is the only one whose identity is certain. It is 23 mm. across the disk and the arms are nearly 140 mm. long. The upper surface is uniformly black (really, deep purplish brown) except that the terminal part of each arm is indistinctly banded. Orally there is much white on the oral papillæ, madreporite, under arm-plates, spines and tentacle-scales within the disk ; otherwise the lower surface is uniformly dark.

The young specimen from Station 164 is hopelessly immature, and its identification is open to question. So, too, with the nine from an unknown locality, young ones (3–12 mm. across the disk) in very poor condition. The colour is conspicuously light (cream colour through red-brown and grey-brown to dusky brown), probably the result of artificial bleaching. One cannot be sure of the identification, but there is no other known species to which they may be referred.

Remarks.—It is a little remarkable that more adult Ophiocomas were not secured, but the explanation is probably found in the very small amount of really littoral collecting that was done.

Family **OPHIODERMATIDÆ.**

Ophiurodon cupidum (Koehler).

Ophioconis cupida Koehler, 1905, p. 15 ; pl. 1, figs. 19 and 20.
Ophiurodon cupida Matsumoto, 1917, p. 315.
Ophiurodon cupidum Koehler, 1930, p. 278.

Localities :

Station 45 ; South Arabian coast ; 38 metres. One specimen.
Station MB I*b* ; Red Sea ; 29 metres. One specimen.
Station MB I*d* ; Red Sea ; 26 metres. One specimen.

Range.—Philippines to Kei Islands, 13–60 metres.

Notes.—The Red Sea specimens, which measure about 5 mm. across the disk and have arms 15–20 mm. long, are in very good condition, but the one from Station 45 has received rough treatment and is badly damaged. It is, however, undoubtedly conspecific with the other two. In all of the specimens the disk is noticeably flat, thin and circular ; pale brown where covered with the minute granules, but white where these are rubbed off. The arms are distinctly banded with dusky, the bands being separated by two, three or four light-coloured segments. The very slender arm-spines are white.

Remarks.—Koehler (1922, pp. 13–16) has given a very useful discussion of the old genus Ophioconis and the genera into which Matsumoto (1917, pp. 310–317) broke it. It is now clear that Ophiurodon and Ophiuroconis, at least, must be placed in the Ophiodermatidæ.

Bathypectinura conspicua (Koehler).

Pectinura conspicua Koehler, 1897, p. 322 ; 1904, pl. 1.
Bathypectinura conspicua H. L. Clark, 1909, p. 130.

Localities :

Station 26 ; Gulf of Aden ; 2312 metres. Seventeen specimens.
Station 34 ; Gulf of Aden ; 1022 metres. One specimen.
Station 115 ; Zanzibar area ; 640–658 metres. Twenty-seven specimens.
Station 122 ; Zanzibar area ; 732 metres. One speciemn.

Range.—East Indies and Bay of Bengal, 239–1992 metres.

Notes.—This is a very striking ophiuran and it is represented in the "Mabahiss" collection by a splendid series of 46 specimens. The smallest are only about 20 mm. in disk diameter, but the largest measure 52 or 53 mm. across, larger than any hitherto recorded. The arms in life were apparently about 6 times the disk diameter. In alcohol or dry these specimens range from pale tawny yellow to nearly white in colour, but in life, according to a field note, they were " apricot orange, slightly paler on centre of disk.".

Remarks.—When the genus was established (H. L. Clark, 1909), 7 species were assigned to it, of which 3 had been described by Lyman and 4 by Koehler. An eighth species was added by Matsumoto in 1917. But in 1922, Koehler, faced with 24 specimens from 17 "Albatross" stations in the Philippines and East Indies, concluded that there were but 3 valid species, *heros*, *lacertosa* and *reducta*, but not having sufficient material of Lyman's species for comparison, he continued to use the name *conspicua* for the big East Indian species collected by the "Albatross". There is no doubt that this is the species taken by the " Mabahiss " and Koehler's name is used here, as I have no material of *heros* for comparison and only single specimens of *lacertosa* and *tessellata*—Lyman's West Indian species. Koehler is very sure that Matsumoto's Japanese species *gotoi* is identical with *conspicua*, but the original description and figures incline me to think Matsumoto may have been right in considering it distinct.

Family **OPHIOLEPIDIDÆ.**

Ophiotypa simplex Koehler.

Ophiotypa simplex Koehler, 1897, p. 281 ; pl. 5, figs. 1–3.

Localities :

Station 120 ; Zanzibar area ; 2926 metres. Nine specimens.
Station 171 ; central part of Arabian Sea ; 3840–3872 metres. Fourteen specimens.

Range.—Bay of Bengal, in very deep water (3595 metres).

Notes.—These interesting specimens are in perfect condition except for the loss of an arm-tip or two in most of them. They range in disk diameter from 3 to 6 mm. and in arm-length from 4 to 7 mm. The largest specimen has the arms 6 mm. long, almost

exactly equalling the disk, while the specimen with the longest arms has the disk scarcely 4 mm. across. In the smallest specimen the arms are 4·5 mm. long. In their present condition the specimens are white, but the huge primary plates have a slight greyish tint, lacking on the arms and small disk-plates. There is no note as to the colour in life. One of the specimens from Station 171 has an interradius almost wholly wanting dorsally, so that two of the arms are closely side by side at disk margin. Orally the jaw in that interradius is minute and imperfectly developed.

Remarks.—The rediscovery by the "Mabahiss" of this remarkable deep-sea ophiuran, hitherto known only from the two specimens taken by the "Investigator", is one of the most interesting of her zoological "finds". Several of the present specimens are notably larger than the types and their arms are apparently better preserved. The depth at which they were taken at Station 171 is even greater than that of the "Investigator" station.

Ophiopyrgus alcocki Koehler.

Ophiopyrgus alcocki Koehler, 1897, p. 283; pl. 5, figs. 4–6.

Localities:

Station 119; Zanzibar area; 1207–1463 metres. Fifteen specimens.

Station 171; central part of Arabian Sea; 3840–3872 metres. Three specimens.

Range.—Bay of Bengal, in very deep water (2358 metres).

Notes.—These specimens, which range from 3 to 6 mm. in disk diameter are in excellent condition, except that the tips of the rather abruptly attenuate arms are always broken. In several cases, however, enough of the tip is present to show that the arms are fully twice the disk diameter and perhaps are a little longer than that. The colour is quite uniformly white.

Remarks.—This is another of the remarkable ophiurans discovered by the "Investigator" (though she took but a single specimen) and now rediscovered by the "Mabahiss". The largest of the present series is not quite so large as the unique holotype. Neither in his original figures, nor in those published later in the final "Investigator" report (1899), does Koehler attempt to show the roughly granular surface of the large plates, though he refers to it in the description. Under a magnification of 90 diameters these granules are seen to have glassy tips; on the large disk-plates they are bluntly pointed and scarcely to be called granules, but on the arms (basally only are they present) and orally they are more rounded and granular. The essential features of this striking genus will be found more fully discussed on p. 101.

Ophiomastus tumidus Koehler.

Ophiomastus tumidus Koehler, 1897, p. 285; pl. 5, figs. 7–9.

Localities:

Station 119; Zanzibar area; 1207–1463 metres. Seven specimens.

Station ? One specimen.

Range.—Bay of Bengal, in very deep water (2358 metres); also in the East Indies at lesser depths (301–1158 metres).

Notes.—These specimens range from less than 3 to about 3·5 mm. in diameter, confirming Koehler's view based on both the "Investigator" and "Siboga" collections

that specimens 4 mm. across the disk are adults. The present series is in excellent condition, but calls for no special comment. It is probable that the one from an unknown station was taken at Station 119.

Remarks.—Again we have here an "Investigator" discovery confirmed by the "Mabahiss", and it is interesting to note that the "Mabahiss" specimens were taken in company with *Ophiopyrgus alcocki* just as were those of the "Investigator". It is curious that the "Siboga" met with *tumidus* in very much shallower water than it inhabits in the Bay of Bengal or off Zanzibar.

Ophiomastus platydiscus* sp. nov. (Text-fig. 42.)

Locality.—Station 120; Zanzibar area; 2926 metres. One specimen.

Description.—Disk low rounded conical, 4 mm. in diameter and almost 2 mm. high. Arms 5, short, terete and rigid, about 8 mm. long when complete, but all are broken; one, however, is very nearly perfect. Disk covered by a huge central plate more than 1·5 mm. in diameter, 5 large radials, 5 pairs of rather small radial shields, and 3 plates in a linear series in each interradius, of which the marginal is largest and the most proximal is smallest. Radial shields heptagonal, widest proximally, the longest side, adjoining the interradial marginal plate, may be quite concave; the shields are in contact along their inner margins. Distally between them is a somewhat swollen triangular plate, wider than long, which may be a disk-plate, but it seems better to call it the first upper arm-plate. Appressed to its distal margin is the pentagonal second upper arm-plate, also wider than long; the succeeding plates are triangular with a convex distal margin; they decrease steadily in size distally, and the distance between them increases correspondingly. All disk and side and lower arm-plates are conspicuously shagreened, the upper arm-plates and oral shields and plates somewhat less so.

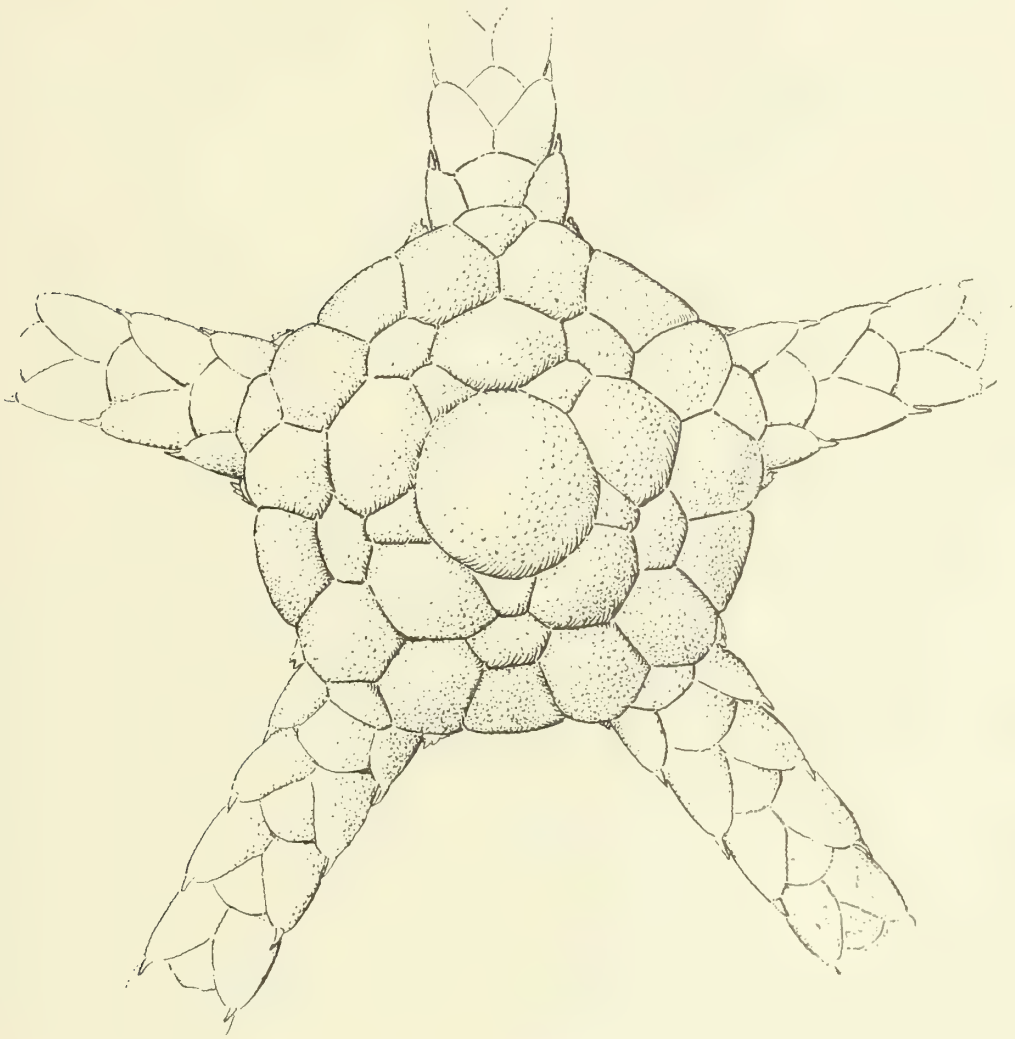
Interbrachial areas below small, covered by a pair of small swollen plates, the small short genital plates and the huge oral shield. Genital slits short, confined to area near arm-base, with notably crenulate margin, due to 6–8 low, rounded papillæ (arm-comb) on the genital scale. Under arm-plates small, much longer than wide, oblong with rounded corners, wider distally than proximally, completely separated, except the first two, which are relatively large and broadly in contact; the first is somewhat triangular, wider than long, the second is more pentagonal and longer than wide; distally the under arm-plates become squarish or rounded and very minute. Side arm-plates large, somewhat swollen; seen from below they are oblique in position; on the distal margin, each carries 3 minute, slender, well-spaced arm-spines, not one-fifth as long as the plate. Tentacle pores, relatively large, one on each side of each under arm-plate; on the first (oral) pore there are 3 (rarely 2) scales on the outer side, 2 on the inner; the next pore shows 2 on the outer side and a rudiment on the inner; the third pore has a single scale on the outer side; subsequent pores have no scales.

Oral shields large, pentagonal, somewhat swollen; inner angle very acute, the others rounded; length and breadth nearly equal. Adoral plates moderately large, much longer than wide, meeting broadly within in front of the oral shield. Oral papillæ wanting, but the compressed edge of the jaw is slightly scalloped, with 5 or 6 minute crenulations, most distinct near apex of jaw. Colour almost white.

* πλατύς = flat + δίσκος = disk, in reference to the form, unusually flattened for this genus.

Remarks.—Although this specimen is unique, it is probably normal and represents an undescribed species. It is interesting to note that its congener, *tumidus*, was taken at Station 119 in water exactly half as deep.

The genus Ophiomastus has never been properly defined, and the line between it and Ophiopyrgus has never been clearly drawn. Mr. Lyman based each genus on a single peculiar species, collected by the " Challenger ". Of Ophiomastus he had three specimens ; of Ophiopyrgus two (or more ?). The general appearance of the two species was so different



Text-fig. 42.—*Ophiomastus platydiscus* sp. nov. Dorsal view of disk and arm-bases. × 17.

that he apparently did not consider them very nearly related, but as the number of species known in each genus has increased the line between them has become difficult to draw. In his diagnosis of Ophiomastus, Lyman does not mention a single valid character to separate it from Ophiomusium, for oddly enough he does not refer to the tentacle pores, the obvious feature by which the genera are to be distinguished. Ophiopyrgus is designated as " the most singular-looking genus yet found among Ophiuridæ ", but its " peg-like central primary plate " seems to be the basis of that opinion. However, Lyman refers to its tentacle-pores as " peculiar " and makes them a special feature of his diagnosis. To

appreciate the two genera and appraise them properly, we must go back to Lyman's two species, and study them anew.

Of *Ophiomastus tegulitius* a type specimen is at hand, and examination need not be very detailed to show that it cannot be placed in any genus known in 1878. Its really distinctive characters are the continuous series of tentacle-pores and scales on the short flattened attenuate arms, the high disk covered by the relatively huge, hemispherical primary plates, the swollen adorals and the apparent lack of oral papillæ. Lyman describes and figures (1882, p. 100 ; pl. 8, fig. 16) 3 very low, wide oral papillæ on each side of the jaw, but in the co-type, a magnification of 90 fails to reveal any sutures along the edge of the jaw. Lyman says the papillæ " are so closely soldered as to form an almost continuous narrow line from side mouth shields to apex ". In *Ophiomastus secundus* of the West Indies, the oral papillæ are " represented only by a narrow border along the sides of the mouth frames with one large and much swollen one at apex of jaw ", according to Lyman's original description and figures. This describes the condition in *O. tumidus* Koehler and in the present species, *platydiscus*. Matsumoto (1917, p. 234) places Ophiomastus in a group of 5 genera in which the " basal lateral arm-plates " are " extraordinarily widened ". He apparently had not seen a specimen of the genus, but Lyman's figures give no warrant for such an idea ; the basal arm-plates are relatively big and swollen, but they are not abnormally widened, nor are they, it may be added, in Ophiotypa, which Matsumoto places in the same group.

Koehler (1922, pp. 352–355) has discussed the matter of the position of the second pair of oral tentacle-pores in the Ophiolepididæ, pointing out the inaccuracy of referring to them as ever really opening into the mouth-slits, and questioning therefore the validity of Matsumoto's division of the family into two sub-families. Certainly in Ophiomastus, however, there is no question about their position, for they lie close beside the first under arm-plate well away from the oral slits. Another point to which Koehler refers incidentally (p. 357) is the presence in Ophiopyrgus of a " radial comb ", implying that " radial papillæ " are wanting in Ophiomastus. I do not think this is a feature on which we can lay much weight, for such a comb is well developed in the present species (*platydiscus*), and is very rudimentary in the type-species of Ophiopyrgus.

We may then define Ophiomastus as follows :

A genus of Ophiolepididæ in which the disk is covered more or less completely by the primary plates, radial shields and one or more interradial plates ; the central plate is disproportionately large, while the radial shields may be so small as to be more or less concealed by the big radials. Adoral plates notably big and swollen. First under arm-plates largest or at least nearly equal to second ; succeeding plates diminishing rapidly in size ; each plate is accompanied nearly or quite to the tip of the arm, by a pair of pores ; the basal pores have tentacle-scales on both the side arm-plate and the under arm-plate, but succeeding pores have only one scale (side arm-plate) or none. Oral papillæ wanting, but the compressed margins of the jaw may be more or less distinctly crenulate.

Genotype : *Ophiomastus tegulitius* Lyman.

Including the species herein described there are now known nine species of the genus ; arranged in the order of their description they are as follows :

O. tegulitius Lyman, 1878.
O. secundus Lyman, 1878.
O. texturatus Lyman, 1883.

O. tumidus Koehler, 1897.
O. ludwigi Koehler, 1900.
O. perplexus Koehler, 1904.
O. planulatus (Koehler), 1922, as an Ophiopyrgus.
O. melaniecæ Hertz, 1927.
O. platydiscus H. L. Clark, 1939.

Of these *ludwigi* should probably be made the type of a new genus, its disk and upper arm-plates, as well as the proximal tentacle-pores setting it apart from the other members of the genus, but without a specimen at hand for examination it would be unwise for me to propose a generic name. Koehler's *Ophiopyrgus planulatus* is unquestionably an Ophiomastus and hence is listed here (see p. 102). The present species *platydiscus* may be readily distinguished from its congeners by the relatively low disk and the arrangement of its plates, the narrow, terete and rigid arms and the crenulate margins to the jaws and to the genital scales.

The genus Ophiopyrgus is similar to Ophiomastus in several features, and a sharp line between them has never been drawn. Matsumoto apparently never saw either, and Lyman places them so far apart in his classification it may fairly be inferred that he did not consider them very nearly related. Studer (1882, p. 9) hints at a relationship, but does not discuss either the resemblance or differences. Koehler, who has added 5 species to Ophiopyrgus, does not seem to have ever attempted a definition, for in my opinion, he has included two, and possibly three genera under the name. It is important, therefore, to define Ophiopyrgus clearly as shown by the characters of the genotype, of which a co-type is in the Museum of Comparative Zoölogy collection. The following definition is the result of very critical study of this co-type of *wyville-thomsoni* as well as of the specimens in the " Mabahiss " collection of its nearest congener, *alcocki*. Ophiopyrgus is a genus of Ophiolepididæ in which the disk is extraordinarily high, so that the radial shields are nearly or quite vertical in position ; the great central, more or less conical plate, with 5 large primary radials, covers most of the upper side of the disk, but the primary interradials may be plainly visible from above. Arms short, wide at base, but tapering abruptly, the distal segments being very long and slender. Upper arm-plates only 3 or 4 at very base of arm, the first of moderate size relatively, but the others minute. Three basal tentacle-pores relatively large, with 3–6 scales on each (both sides of pore) ; subsequent pores minute with one scale or none. Adoral plates insignificant. Oral papillæ present.

Genotype : *Ophiopyrgus wyville-thomsoni* Lyman.

There are, in my judgment, but two species in the genus, for Koehler's *alcocki* is the only subsequently described species which seems to me really congeneric with Lyman's. Studer's *saccharatus* and Koehler's *trispinosus* and *depressus* form a distinct group which may be called Ophiopyrgoides, and for which I propose *Ophiopyrgus trispinosus* Koehler as genotype. The disk is not exceptionally high, but is covered as in Ophiomastus with large primary plates and radial shields. Arms rather short and attenuate, the distal joints not elongate. Upper arm-plates present throughout most, if not all, of the arm-length, of moderate size basally. Basal tentacle-pores large with several scales on each side, but they become smaller distally with fewer scales, and the most distal have but a single scale. Adoral plates of moderate size. Oral papillæ small but evident. Radial comb on genital plates well developed. The species comprised by this genus are known as yet only from the East Indies and Fiji Islands in 1150–2058 metres.

Koehler's *Ophiopyrgus planulatus* from Celebes (1922, p. 355), based on a single specimen less than 5 mm. across the disk, is so obviously an Ophiomastus it is hard to see why the describer overlooked the fact. On the other hand, the same author's *O. australis* (1901, p. 24), based on a single specimen scarcely 2 mm. across the disk and obviously very young, taken in the Antarctic Ocean at 600 metres, is of dubious affinity, but is probably an Ophiopyrgoides, or represents an as yet unnamed genus.

OPIOCHORUS* gen. nov.

Ophiolepids with a markedly convex disk, covered much as in Ophiomastus by the primary plates and radial shields. Upper arm-plates practically wanting, though the first one or two may exist. First under arm-plate large, second smaller, subsequent plates rudimentary or wanting. Oral shields and adoral plates large and somewhat swollen. First tentacle pore (second oral pore) large, with 2 or 3 scales on either side ; second pore small, with a rudimentary scale or none ; subsequent pores small and naked, placed far out on the side arm-plate at the base of the lowest (or lower) arm-spine. Oral papillæ wanting, the edges of the jaw as in Ophiomastus.

Genotype : *Ophiochorus granulatus* sp. nov.

The species upon which this genus is based is apparently a specialized Ophiomastus, in which the upper and under arm-plates have virtually disappeared and the tentacle-pores have moved out on to the sides of the arm. It is found in very deep water, like its nearest allies, and will probably be found widely distributed in the Indian and East Indian seas.

Ophiochorus granulatus† sp. nov. (Text-figs. 43 and 44.)

Localities :

Station 120 ; Zanzibar area ; 2926 metres. Twenty-four specimens.

Station 171 ; central part of Arabian Sea ; 3840–3872 metres. Seventy specimens.

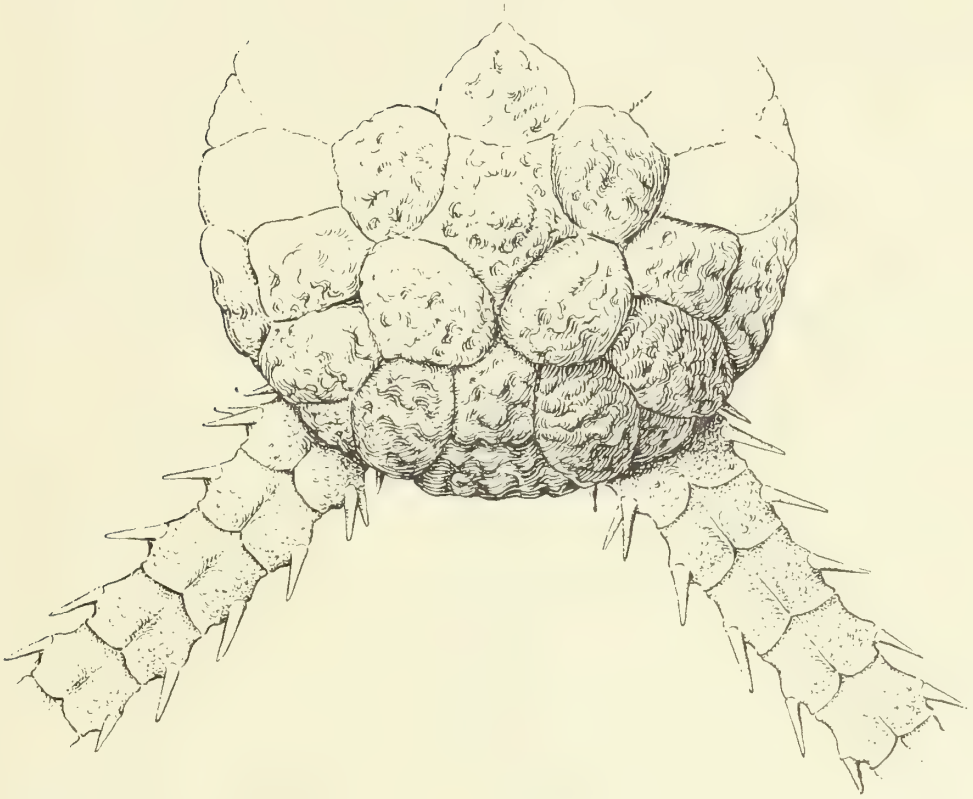
Description.—Disk 4 mm. in diameter, markedly convex. Arms 5, apparently about 10 mm. long, the distal joints long and nearly cylindrical, but not notably so. Disk covered by the primary plates and radial shields, with a second interradial plate of large size forming the margin of the disk ; all the plates are convex or somewhat swollen, with rough, sculptured and pitted surface ; the lines between them are difficult to detect. Between the distal ends of the radial shields is a triangular plate with a similar surface and hazy boundaries which is apparently the first upper arm-plate, though it is placed on the disk margin rather than on the surface of the arm. No other upper arm-plates can be detected, but the surface is so rough and irregular it is possible that rudiments persist on the basal part of the arm.

Interbrachial areas below covered by the big marginal plate and the oral shield which is rounded pentagonal and a little swollen ; its surface is shagreened but not sculptured. No genital slits are visible and the genital scales seem to be rudimentary. First under arm-plate longer than wide, wider distally than proximally ; it is not quite so large as an adoral plate ; second plate small, more triangular, about as wide as long ; subsequent

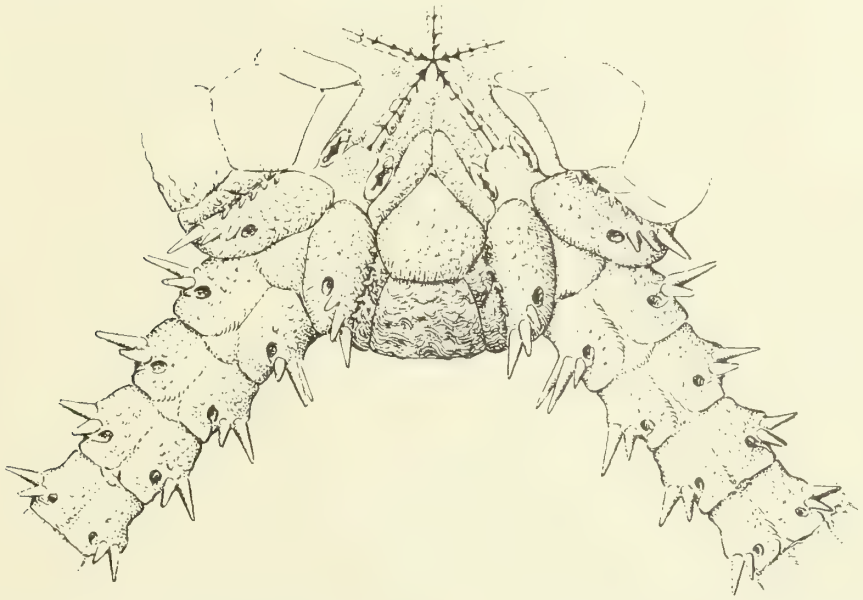
* Ophio — + χῶρος = a space, in reference to the wide space between the two tentacle-pores in each pair.

† *granulatus* = having a granulated surface, in reference to the large granules on the disk-scales.

TEXT-FIG. 43.



TEXT-FIG. 44.



TEXT-FIGS. 43, 44.—*Ophiochorus granulatus* sp. nov. FIG. 43.—Dorsal view of half of disk and two arm-bases. × 16. FIG. 44.—Oral view of same. × 16.

plates wanting as a rule, but the third and rarely the fourth can be detected. Side arm-plates very large relatively, as they make up the whole arm ; the first pair are somewhat swollen orally and separate widely the first and second under arm-plates ; as these swollen plates are larger than the adorals and have a coarsely pitted surface they give a peculiar appearance to the oral frame. Arm-spines very small and sharp ; there are 3 on the basal segments, then 2 and distally they seem to disappear ; those at the base of the arm are somewhat bristling, but for the most part they are appressed to the arm-plates. Tentacle pores beside the first under arm-plate relatively big and slit-like, with 2 or 3 rounded scales on either side much as in Ophiopyrgus. The pores beside the second under arm-plate are circular and have but a single scale or none ; subsequent pores small, circular, with no scale, located at the base of the lowest (or lower) arm-spine ; hence they are well out on the side of the arm and the two of a pair are separated from each other by nearly the full width of the arm.

Oral shields relatively large, about as wide as long, rounded pentagonal, with the narrowest angle at the proximal end. Adoral plates small, quadrangular, longer than wide, meeting broadly within, lying as they do against the proximal angle of the oral shield. Oral plates of about the same size and form as the adorals, but somewhat depressed below them. Oral papillæ wanting as in Ophiomastus, but the jaw margins are compressed and slightly scalloped, with 3 or 4 low, wide crenulations on each side. Teeth concealed by the pointed termination of the jaw. Colour dingy white.

Remarks.—The holotype is from Station 171, but the paratypes from Station 120 are so exactly like those from Station 171 that if the two lots were mixed in a single tray the Zanzibar specimens could not be picked out with any certainly. The entire series of specimens range from 3 to 5 mm. in diameter, but the diversity in height is insignificant, as the vertical diameter is about 2 mm. in each one. The central plate, however, shows more diversity, for while it may be only a little convex, especially in large specimens, it is generally a more or less distinctly 5-sided pyramid, especially in the smaller specimens. There is also diversity in the pitting and sculpturing of the plates, which is much more noticeable in some specimens than in others, but there is no evident correlation in this with size. In all specimens the arms are broken, but in several the damage is only at the very tip ; they seem to be normally in life a little more than twice the disk diameter.

OPHIURASTER* gen. nov.

Ophiolepids with relatively large flat disk, from which the wide flat arms are not sharply set off. Radial shields very large, occupying the entire disk margin on the aboral surface and appearing orally as pairs of huge interradial plates, against which the tiny oral shields and very large adoral plates abut. Upper and under arm-plates very small, but present nearly or quite to tip of arm.

Genotype : *Ophiuraster perissus* sp. nov.

This little brittle-star could be easily mistaken for a sea-star at first sight, the outline being almost identical with that of some Goniodiscasters. Of course, even a hasty examination shows that it is not in any way an asteroid, but simply an ophiuran in which the radial

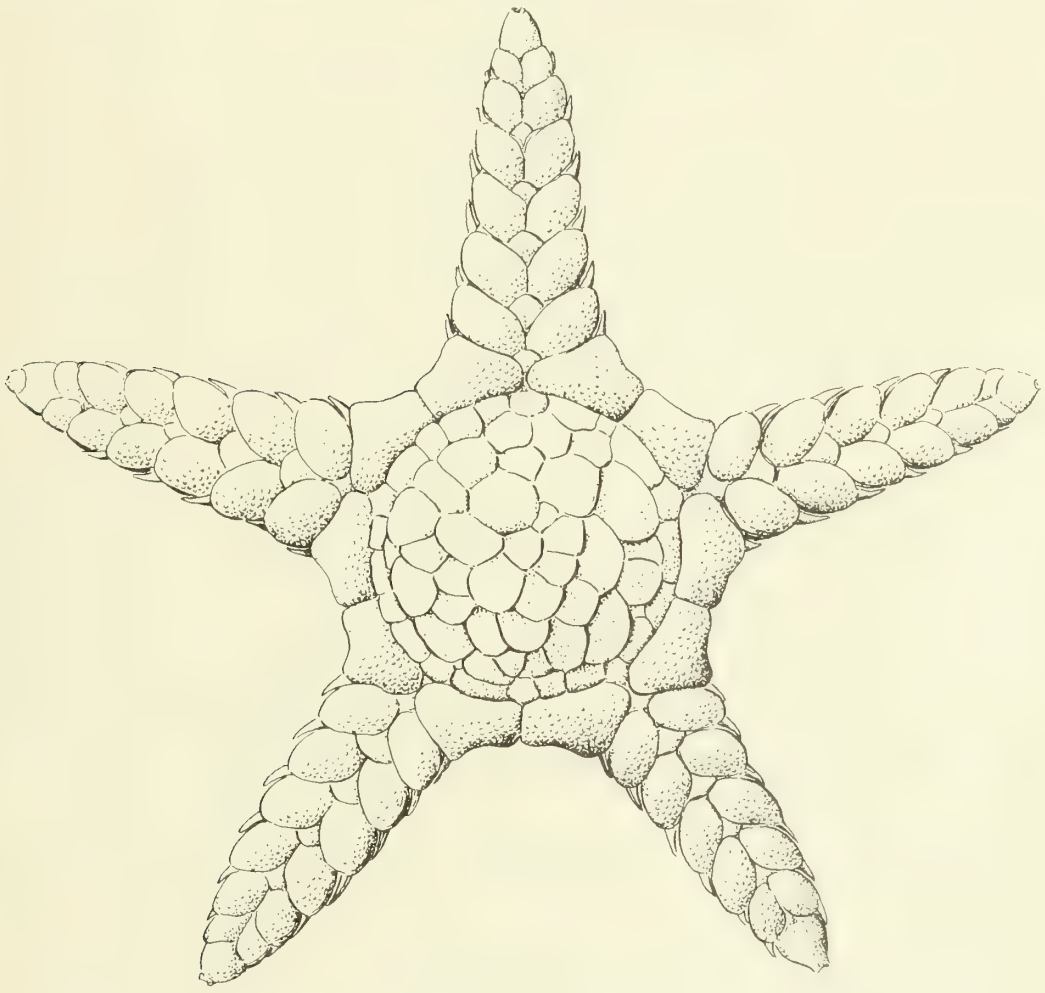
* A combination of Ophiura and Aster (the root of Asterias) in reference to the extraordinarily asteroid appearance of this ophiuran.

plates have become enormously enlarged and the interbrachial areas below completely pre-empted by them. The usual sharp distinction between disk and arms is thus obscured. It is not easy to say with what genera Ophiuraster is most nearly allied, but it seems to be a deep-water form, and is probably related as nearly to the three preceding genera, especially Ophiomastus, as to any others of the Ophiolepididæ.

Ophiuraster perissus* sp. nov. (Text-figs. 45 and 46.)

Locality.—Station 26 ; Gulf of Aden ; 2312 metres. One specimen.

Description.—Disk 4 mm. in diameter, very flat, definitely decagonal. Arms 5, very flat, a little more than 3 mm. long, 1·5 mm. wide at base, bluntly pointed. Disk



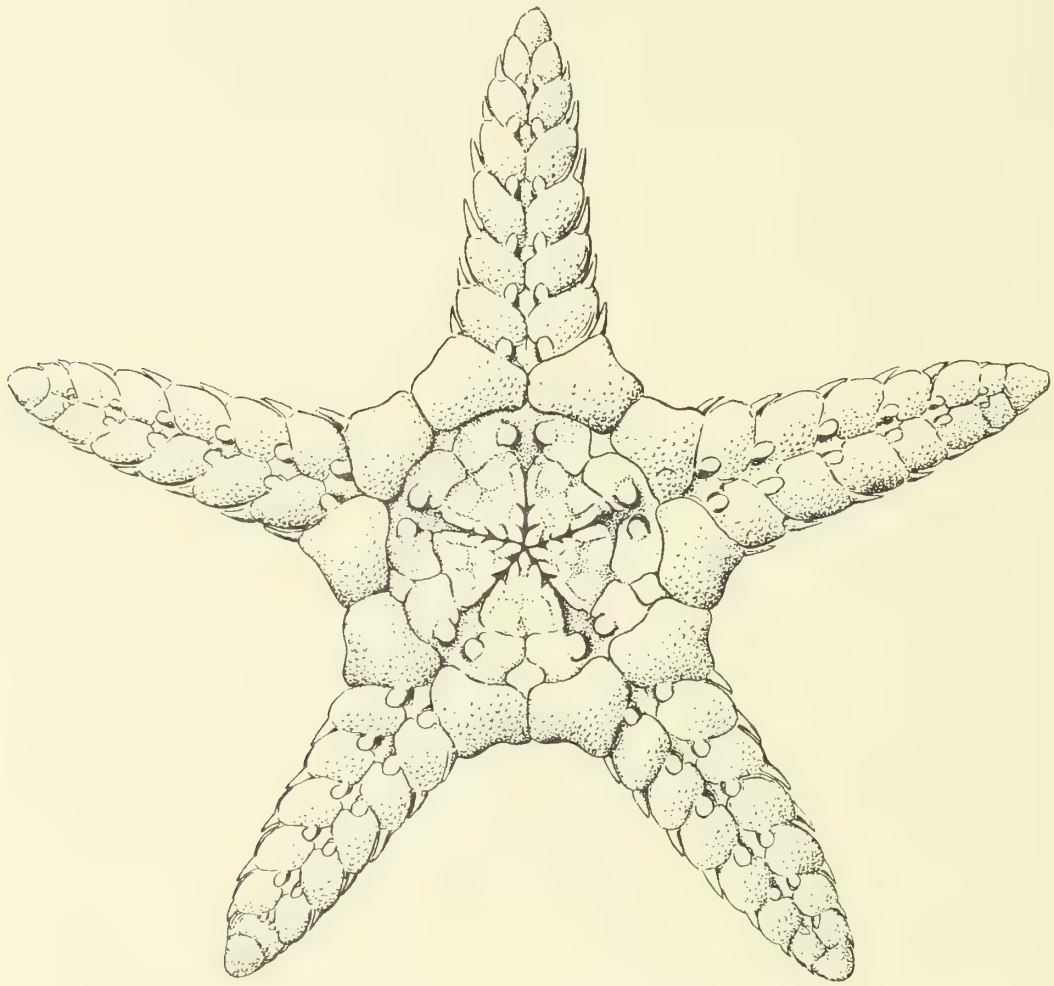
Text-fig. 45.—*Ophiuraster perissus* sp. nov. Dorsal view of entire animal. × 14.

bounded by the 10 huge, radial shields, which enclose a circular area 2·75 mm. in diameter, nearly flat, but a little convex, covered by 40–50 plates or scales, arranged apparently without definite order ; the outermost series is low and wide, and within it are 5 rather large radial plates and 4 about equally large plates at centre of disk ; the remaining plates are small and of irregular distribution. There is no definite central plate. Radial shields

* περισσός = *extraordinary ;* of obvious significance.

thick, slightly swollen, wider than long, with angles rounded; radially the two of a pair are just barely separated, but interradially the plates are broadly in close contact. Upper arm-plates 4–6, minute, diamond-shaped, wider than long, not even nearly in contact; those that should be distalmost appear to be wanting.

Interbrachial areas below wanting, the space being occupied by the extraordinary radial shields which meet not only in the interradial line, but also radially, separating the



TEXT-FIG. 46.—*Ophiuraster perissus* sp. nov. Oral view of entire animal. × 14.

first and second under arm-plates. These plates are minute and deeply depressed, much longer than wide, with lateral margins concave, due to the large tentacle-pores; the plates are very widely separated from each other, but seem to continue to the tip of the arm. Side arm-plates relatively large and swollen, meeting broadly above and below; each plate carries a single relatively large, thick, opaque, bluntly pointed arm-spine, half as long as the segment; on a few segments a second, similar but somewhat smaller spine occurs. Tentacle-scale single, thick, almost circular, nearly or quite as large as the distal under arm-plates.

Oral shields very small, rounded diamond-shape or roughly triangular, smaller

sometimes than the big tentacle-scale of the second oral pore. Adoral plates large, rhombic, meeting broadly within but separated without by the first under arm-plate. Oral plates very large, but their outlines are hard to make out. Each carries 2 (rarely 3) ill-defined oral papillæ, of which the distal is very low and wide, the proximal (1 or 2) narrow but flat, somewhat erect and bluntly pointed. Apex of jaw occupied by a single large, flat, rounded-triangular papilla ; this may be the lowest tooth ; it completely conceals any that may be above it. Colour of dry specimen pure white.

Remarks.—As there is only a single specimen of this remarkable ophiuran, I am not at liberty to dissect it, so that certain details of structure must remain unknown until more material is secured. There is no trace of genital slits, a structural anomaly which it shares with Ophiomastus and Ophiotypa. The largest specimens of Ophiopyrgus show narrow but definite slits alongside the huge oral shields. In a large Ophiotypa there is a minute and insignificant pit at each outer corner of the oral shield which might be construed as the last trace (or the first indication) of a genital slit, but I should hesitate to so construe it.

Amphiophiura convexa (Lyman).

Ophioglypha convexa Lyman, 1878, p. 84 ; pl. 3, figs. 83, 84.
Amphiophiura convexa Matsumoto, 1915, p. 77.

Localities :

Station 120 ; Zanzibar area ; 2926 metres. Seven specimens.

Station 171 ; central part of Arabian Sea ; 3840–3872 metres. Ten specimens.

Range.—North-western Pacific and tropical Atlantic, in very deep water, 3120–4140 metres.

Notes.—The specimens from the two widely separated stations show no constant differences and are essentially indistinguishable. They range in disk diameter from 4·5 to 11 mm. and the arms are (or were) not quite 3 times as much. When not missing, the tips of the arms are rolled inward prettily in the horizontal plane.

Remarks.—This species has been fully and ably discussed by Koehler (1914), and these specimens throw little light on its diversity. The resemblance to *bullata* Wyville Thomson is very marked orally, and in the structure and details of the arms, but the big primary scales of the disk are of a different character and even if somewhat separated by small scales (in very large specimens) they are quite distinctive. The occurrence of *convexa* in the " Mabahiss " collection is very interesting, as it increases the known geographical range enormously. The species has not hitherto been taken in the Indian Ocean or even in the East Indies.

Amphiophiura paupera (Koehler).

Ophioglypha paupera Koehler, 1897, p. 290 ; pl. 5, figs. 12, 13.
Amphiophiura paupera Matsumoto, 1915, p. 77.

Localities :

Station 25 ; Gulf of Aden ; 620 metres. One specimen.

Station 109 ; Zanzibar area ; 640 metres. Seven specimens.

Station 122 ; Zanzibar area ; 732 metres. One specimen.

Station 143 ; Maldive area ; 797 metres. Thirty-seven specimens.

Station 158 ; Maldive area ; 786–1170 metres. Six specimens.

Range.—China Sea, near southern Luzon to Laccadive Islands in 743–1289 metres.

Notes.—This is a fine series of specimens, particularly those from the Maldive Islands. They range in disk diameter from 4·5–9 mm. in diameter, with the arms rather more than twice as much. The arms are apparently flagellate and delicate at tip ; in no specimen is there a perfectly complete arm. In colour the specimens range from pure white to pale yellowish ; one is dull purplish, but this is obviously artificial.

Remarks.—Originally taken by the " Investigator " on the Malabar coast and in the Laccadive Islands, the species has been reported subsequently only by Koehler (1922), who discovered a single specimen in the "Albatross " Philippine collection. Its occurrence in the Maldive Islands would be naturally expected, but the extension of the range by the " Mabahiss " to the Gulf of Aden and to the Zanzibar area is very interesting.

Amphiophiura sculptilis (Lyman).

Ophioglypha sculptilis Lyman, 1878, p. 84 ; pl. 4, figs. 115, 116.
Amphiophiura sculptilis Matsumoto, 1915, p. 77.

Localities.—Station 120 ; Zanzibar area ; 2926 metres. Eight specimens.

Range.—North-western Pacific, near Japan, East Indies, Indian Ocean, Antarctic Ocean and Atlantic Ocean, 457–2959 metres.

Notes.—The specimens from Station 120 are adults, 9–15 mm. across the disk, and there is no question as to their identity.

Remarks.—The " Valdivia " has already discovered this brittle-star in the Zanzibar region, and Hertz says that young ones (6 mm. in diameter) are much like those of *convexa*, but the number of plates is not so reduced, and the calcareous structure is less coarse.

Amphiophiura trifolium Hertz.

Amphiophiura trifolium Hertz, 1927, p. 78 ; pl. vi (by error vii), figs. 14, 15.

Localities :

Station 118 ; Zanzibar region ; 1789 metres. Thirty-five specimens.
Station 135 ; Maldive area ; 2727 metres. Six specimens.
Station 155 ; Maldive area ; 2249 metres. Fifteen specimens.

Range.—Off British East Africa, 1289–1644 metres.

Notes.—Although these 56 specimens are more or less damaged (there is not a single entire arm in the possible 280), they make an excellent series of this little known species. The disk diameters range from 4 to 11 mm., with the large adults having a vertical diameter of 3 mm. The disk is thinnest in the small specimens, but the number of plates is considerable and the general appearance is much as in the adults. The specimens are all white, or nearly so.

Remarks.—The " Valdivia's " specimens, which were the types of this species, were all young, the largest only 7 mm. across the disk. The adults taken by the " Mabahiss " show considerable resemblance to *sculptilis* in the scaling of the disk, the short, wide radial shields, broadly in contact, and the character of the arm-comb, but the upper arm-plates not including the basal ones are oval or elliptical and not at all diamond-shaped or triangular, and they remain in contact somewhat further out on the arm. Orally the conspicuously trefoil shape of the big oral shields distinguishes the " Valdivia's " species

at once, while the very narrow adoral plates are a good additional character. The minute peg-like arm-spines are fewer, shorter and less acute than in *sculptilis* and are found almost wholly on the lower half of the side arm-plates. The collecting of this species in the Maldives as well as off Mombasa by the " Mabahiss ", indicates that it is widely distributed in the western Indian Ocean in deep water. The bathymetrical range was extended quite as notably by the " Mabahiss " as the geographical.

Ophiura æqualis (Lyman).

Ophioglypha æqualis Lyman, 1878, p. 72 ; pl. 3, figs. 74, 75.
Ophiura æqualis Meissner, 1901, p. 925.

Locality.—Station 119 ; Zanzibar area ; 1207–1463 metres. Two specimens.

Range.—Laccadive Islands to the Philippines and south-eastward to New Guinea, 828–2194 metres.

Notes.—These are young specimens, the smaller 4 mm. in disk diameter, the larger 8 mm. They have been compared with specimens of *æqualis* (including a co-type) in the Museum of Comparative Zoölogy and show no notable peculiarities.

Remarks.—This species is interesting because of the presence of scattered, minute, slender spinelets on the disk, and especially in the marginal interradial areas. The extension of its range south-westward to Zanzibar is quite natural, but none the less notable.

Ophiura irrorata (Lyman).

Ophioglypha irrorata Lyman, 1878, p. 73 ; pl. 4, figs. 106–108.
Ophiura irrorata Meissner, 1901, p. 925.

Localities :

Station 26 ; Gulf of Aden ; 2312 metres. Thirty-five specimens.
Station 59 ; South Arabian coast ; 1948 metres. One specimen.
Station 62 ; northern area of Arabian Sea ; 1893 metres. Seven specimens.
Station 119 ; Zanzibar area ; 1207–1463 metres. Four specimens.
Station 120 ; Zanzibar area ; 2926 metres. Fifteen specimens.
Station 135 ; Maldive area ; 2727 metres. One specimen.
Station 171 ; central area of Arabian Sea ; 3840–3872 metres. Two specimens.
Station 185 ; Gulf of Aden ; 2000 metres. One specimen.

Range.—Almost cosmopolitan in very deep water, 1100–4000 metres.

Notes.—This series of 66 specimens ranges in disk diameter from 4 to 26 mm. and shows the usual diversity in disk form, ranging from perfectly circular to pentagonal, with concave sides on the one hand, and, on the other, to decagonal with the radial sides concave and the interradial sides strongly convex, but with the extreme margin nearly straight. Most specimens are quite flat, but some of the circular disks are quite convex. There is much diversity in the shape of the oral shields, the adoral plates, the radial shields and the upper and under arm-plates. Nevertheless there is little doubt as to the identity of these specimens.

Remarks.—Little need be said concerning this much-named species, whose synonymy and distribution have already been discussed by myself (1911) and by Koehler (1914). It may be mentioned, however, that Hertz (1927) places it in a new genus, Ophiuroglypha, and consistently misspells the name as " irrotata ".

Ophiura kinbergi Ljungman.

Ophiura kinbergi Ljungman, 1866, p. 166. H. L. Clark, 1911, p. 37, fig. 9.

Localities :

Station 71 ; Gulf of Oman ; 106 metres. One specimen.
Station 80 ; South Arabian coast ; 16–22 metres. One specimen.
Station MB I*b* ; Red Sea ; 29 metres. Thirty-six specimens.
Station MB I*d* ; Red Sea ; 26 metres. Forty-two specimens.
Station MB II*a* ; South Arabian coast ; 11 metres. Seven specimens.
Station MB II*c* ; South Arabian coast ; 29 metres. Eight specimens.

Range.—Hawaii and Japan to South Australia and eastward to Ceylon, the Malabar coast and North-western Australia ; in shallow water, occasionally down to more than 200 metres.

Notes.—This is an interesting series of specimens ranging from a disk diameter of 2 mm. to adults 10 mm. across. The smallest individual is from Station 71, and is too young to permit positive identification. The finest specimens are the adults from Station MB II*a*, which are of maximum size and show well the characteristic disk-scaling, arm-comb, arm-spines and prettily variegated colouring (somewhat faded, naturally). These specimens (and all the others in this collection) have, however, narrow, somewhat swollen upper arm-plates, especially on the middle and distal parts of the arm, giving an appearance to the upper side of the arm quite different from that of Japanese specimens. But similar plates are characteristic of specimens from Broome, West Australia, and occur even in specimens from New South Wales and Hawaii, so they can hardly warrant a varietal name. The Red Sea specimens are all small, the largest scarcely 6 mm. across.

Remarks.—The discovery of this East Indian species by the " Mabahiss " results in a great extension of its known range, but a very natural one. It may properly be mentioned here that the occurrence of *kinbergi* in the Hawaiian Islands needs verification. The record rests on a specimen in the Museum of Comparative Zoölogy from off Lahaina, Maui, 5–30 fathoms, which was received from a reliable source. There is nevertheless the possibility of an erroneous label or of confusion of specimens from Japan or Australia with what was supposed to be Hawaiian material.

Ophiura lanceolata* sp. nov. (Text-figs. 47 and 48.)

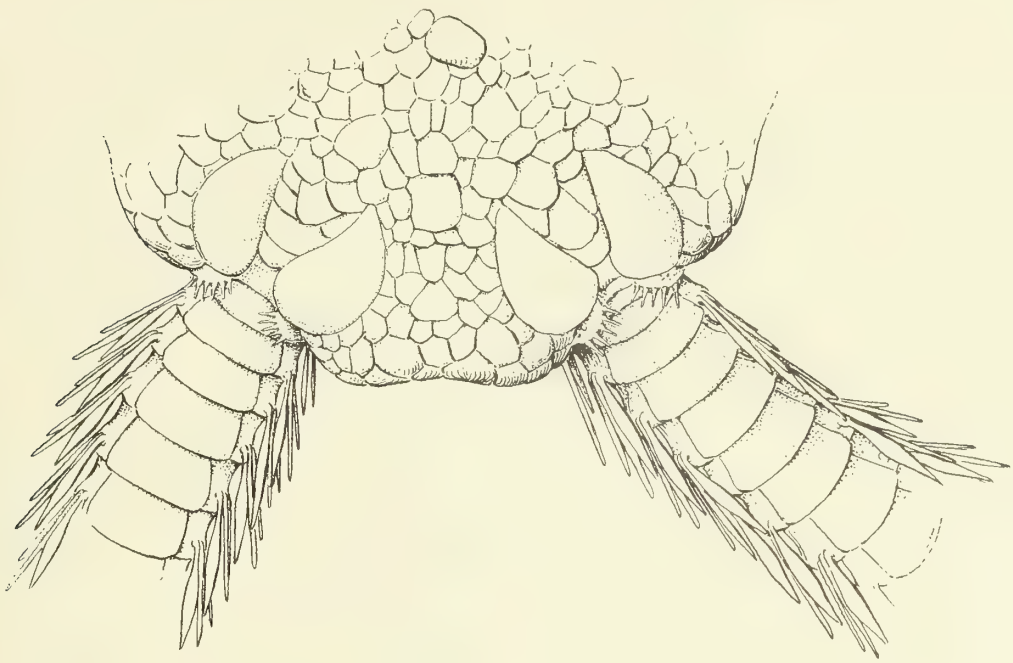
Locality.—Station 153 ; Maldive area ; 256–293 metres. Three specimens.

Description.—Disk 10 mm. across, flat, rounded decagonal, the radial sides concave, the interradial flattened convex. Arms 5 ; all are broken, but they were nearly, and perhaps quite 30 mm. long, rather wide, and somewhat flattened. Disk covered with numerous thin scales of diverse sizes, the larger often more or less surrounded by imperfect belts of smaller ; the primary plates are not easily distinguished ; the largest plates are at the inner end of the radial shields and along the interradial margins. There is a notch in the disk margin at the base of each arm, and the upper ends of the genital scales are noticeable there, each with a conspicuous arm-comb of well-spaced slender, but not very acute spinelets, as long as the second upper arm-plate. Radial shields, about 2 mm. long,

* *lanceolatus* = lance-shaped, in reference to the extraordinary uppermost of the arm-spines.

more than a millimetre wide, pointed within, rounded distally, the outer margin convex, the inner nearly straight ; the two of a pair are well separated by a group of relatively large radial plates proximally and the first 2 upper arm-plates distally. These two plates

Text-fig. 47.



Text-fig. 48.

Text-figs. 47, 48.—*Ophiura lanceolata* sp. nov. Fig. 47.—Dorsal view of nearly half the disk and two arm-bases. × 8. Fig. 48.—Oral view of same. × 8.

are small, the first longer than wide, the second wider than long ; the third and fourth plates are twice as wide as long, or even wider ; succeeding plates are relatively longer, with the distal and proximal margins nearly equal and the lateral margins straight and almost parallel ; beyond the tenth plate the length slowly exceeds the width and the distal

margin becomes convex and more and more exceeds the proximal until at the tip of the arm the plates are longer than wide, triangular, and no longer in contact.

Interbrachial areas below covered by scales similar to those of the disk and the large oral shields ; near the latter the scales are small, crowded and overlapping. First under arm-plate small and ill-defined, but wider than long ; second even smaller, rounded triangular, much wider than long, well separated from the first by a considerable depression ; third plate still smaller, broadly triangular, its width more than twice its length ; succeeding plates becoming decreasingly smaller, losing their proximal angle, until they are tiny quadrilateral plates three or four times as wide as long and separated from each other by practically the full length of the arm segment ; whether they continue to the tip of the arm cannot be determined from these specimens. Side arm-plates large, forming not only the sides, but also nearly the whole lower surface of the arms. Each carries a series of three fragile spines, each about as long as $1\frac{1}{2}$ arm-segments ; the two lower ones are very slender, cylindrical, not very acute, but the uppermost is very flat, widest in the middle, where the width may be as much as one-third the length, narrowed to a slender base and to an acute tip ; these extraordinary lanceolate spines lie with their flat surface against the arm. Owing to their fragile structure many spines are missing wholly or in part. Oral tentacle-pores very large, guarded by 4 or 5 scales on each side ; first arm-pore somewhat smaller, with 3 or 4 scales on each side ; second still smaller, with 3 on each side ; third has 2 small scales and one large elliptical scale ; all subsequent pores with one large flat, rounded scale more than twice as long as wide, the length equalling half the segment-length.

Oral shields very large, 3 mm. long by 2 mm. wide ; they have a wide inner angle with straight sides, slightly concave or notched lateral margins, rounded distal angles and a nearly straight distal margin. Adoral plates long and narrow lying against the inner sides of the oral shield, meeting within and expanding a little distally to separate the shield from the side arm-plates. Oral plates short and swollen, carrying only 3 oral papillæ, a large, unpaired, bluntly-pointed terminal one and a similar but smaller one on each side. In the paratypes there are 2 additional, similar and well-spaced papillæ on each side of each jaw ; their absence in the holotype is probably accidental, perhaps due to the rough handling in the dredge. Teeth narrow and bluntly pointed. Colour (dry) disk pale grey with faint indications of brown and dusky markings, somewhat as in *kinbergi* ; lower surface and arms nearly white.

Remarks.—This fine species is nearly related to *kinbergi*, but the remarkable arm-spines and large distal tentacle-scales are very distinctive. The paratypes are but little smaller than the holotype and except for the oral papillæ resemble it closely. All three specimens are considerably damaged by their rough journey in the dredge. It is quite possible that the arm length really exceeds three times the disk diameter, but as that is the proportion in *kinbergi* it is probably similar in this closely related species.

Homalophiura abyssorum (Lyman).

Ophioglypha abyssorum Lyman, 1883, p. 238 ; pl. 3, figs. 25–27.
Homalophiura abyssorum H. L. Clark, 1911, p. 326.
Ophiurolepis abyssorum Hertz, 1927, p. 93.

Locality.—Station 135 ; Maldive area ; 2727 metres. One specimen.

Range.—Originally taken in the western Atlantic, in 839–1975 metres, it was recorded by Hertz (1927) from the Maldives, in 2253 metres.

Notes.—The " Mabahiss " specimen is a well-preserved adult, 11 mm. across the disk, with slender arms exceeding 30 mm. Comparison has been made with Lyman's type material and no adequate reason for regarding it as distinct has been found. There are details in the scaling of the disk which are unlike what is found in the West Indian specimens, but they are too insignificant to discuss.

Remarks.—Hertz (1927) has already recorded this species from the Maldives, but the confirmation of that unexpected record is very interesting. Why Hertz should have put the species in Ophiurolepis is perplexing, for that genus has for its type *Ophiolepis carinata* Studer, which has certain features quite lacking in *abyssorum*. On the other hand, Lyman's species is clearly a Homalophiura and it is probable that the two other species which Hertz calls Ophiurolepis are really members of that genus. It is probable that Hertz had not critically examined *Ophiolepis carinifera*.

Homalophiura euryplax* sp. nov. (Text-figs. 49 and 50.)

Locality.—Station 184 ; Gulf of Aden ; 1270 metres. Two specimens.

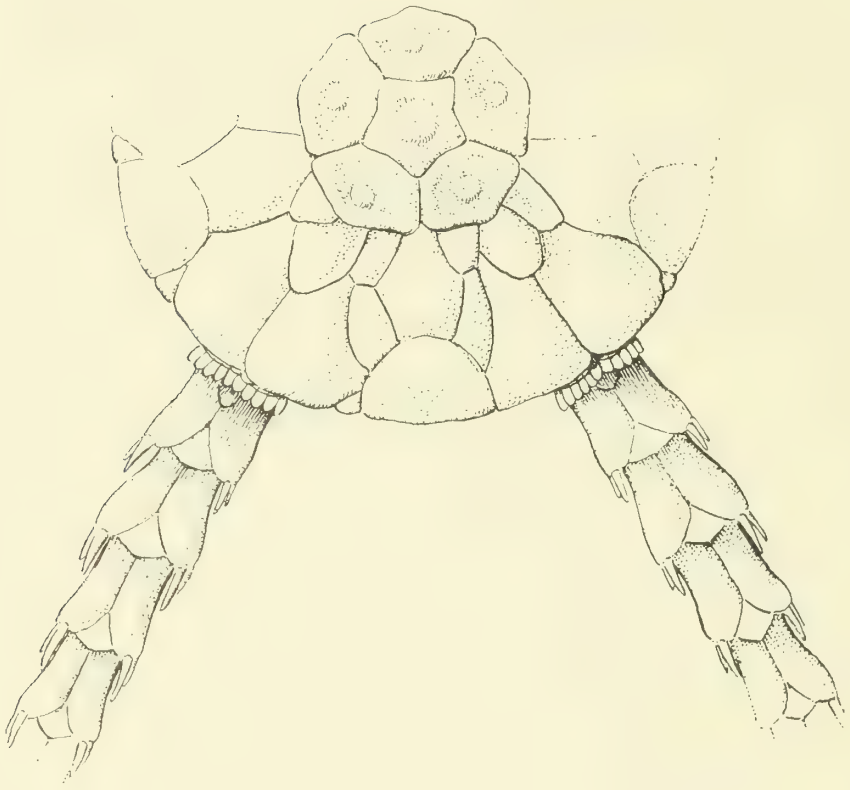
Description.—Disk flat, rounded pentagonal, not quite 6 mm. across. Arms 5, slender, scarcely 16 mm. long, flattened and a little widened at base, the distal end of each segment wider than the proximal. Disk covered by about 40 thin plates and the 10 large radial shields ; 6 primary plates form a compact pentagon at centre, 2 mm. across, each plate bearing a single low and inconspicuous central tubercle. Radial shields large, irregularly triangular, longer than wide ; along inner margin they seem to overlap for about two-thirds of their length (distally) but the inner ends are separated by a single large diamond-shaped radial plate. In each interradius is a large marginal plate, with or without a small plate on each side. Disk margin overlaps base of arms. Arm-comb conspicuous, of 6–8 close-set, blunt, flat papillæ, which do not extend down on the oral surface of the genital scale. Upper arm-plates minute, triangular, widely separated, decreasing in size from the first, which is largest.

Interbrachial areas below covered by about 10 thin, relatively large scales like those of the disk. Under arm-plates small, much wider than long, and widely separated from each other ; the first is somewhat triangular, with the proximal angle truncate ; the second is more nearly pentagonal, but the proximal angle is very wide and the width of the plate is more than twice its length ; succeeding plates nearly or quite quadrilateral, the width 3 times the length, decreasing in size distally and becoming more and more rounded triangular or elliptical with narrowed ends. The first four plates are separated from each other by shallow but obvious depressions. Side arm-plates very large, making up the bulk of the arm ; each plate carries 3 (or 2) slender, bluntly pointed, well-spaced arm-spines, of which the middle or uppermost is longest and may equal (at base of arm) one-half the segment. Oral tentacle-pore relatively large, with 4 flat, rounded scales on each side ; first arm-pore with 3 scales on each side, the outer series continuous with the arm-spines ; second pore similar but smaller, with only 2 scales on each side ; third pore with only 1 scale on each side ; fourth scarcely distinguishable, and none thereafter.

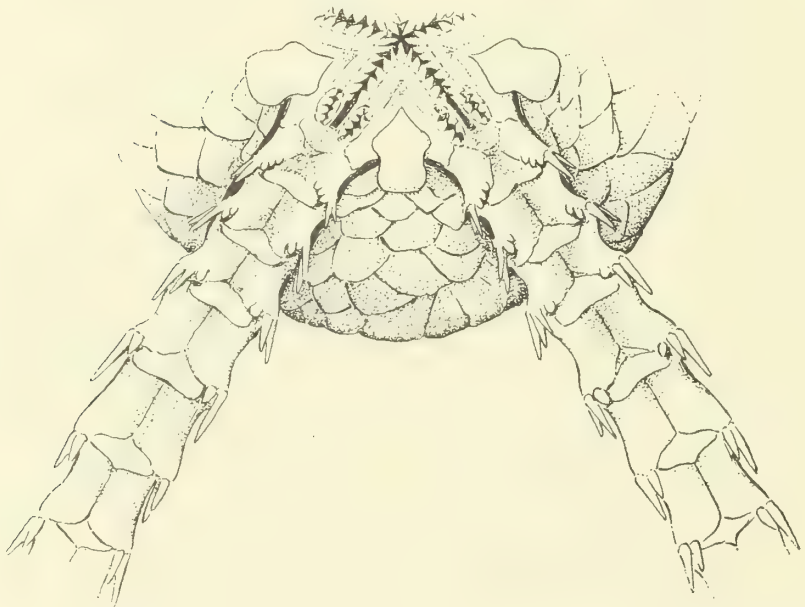
Oral shields very small, more than twice as long as wide, rounded pentagonal, but the

* Εὐρύς = broad + πλάξ = plate, in reference to the extraordinary under arm-plates.

TEXT-FIG. 49.



TEXT-FIG. 50.



TEXT-FIGS. 49, 50.—*Homalophiura euryplax* sp. nov. FIG. 49.—Dorsal view of half the disk and two arm-bases. × 16. FIG. 50.—Oral view of same. × 16.

inner angle may be more or less obscured ; distal end scarcely wider than proximal, lateral margins slightly concave. Adoral plates small and difficult to distinguish. Oral plates apparently larger and somewhat swollen at inner end. Oral papillæ about 6 on each side ; the distal ones are wide, flat, truncate or pointed ; the proximal are bluntly pointed, flat spines ; the unpaired terminal is similar, but is the largest. Colour (of dry specimen) very pale grey, the arms and arm-spines more nearly white.

Remarks.—The paratype is nearly 8 mm. across the disk and is perfectly tetramerous. It differs very little in details from the smaller specimen. The number of disk-scales is naturally fewer and they are relatively larger ; the central group carry no tubercles. The arm-comb is longer, with 15 or more papillæ. The under arm-plates and oral shields are as in the holotype and give a most striking facies to the oral surface, easily distinguishing this novelty from its congeners.

A note with these specimens says that they were found in a 5-lb. jar of worm-tubes, mingled with shells, crustaceans, sponge spicules and " small cinders " !

Homalophiura glypta* sp. nov. (Text-figs. 51 and 52.)

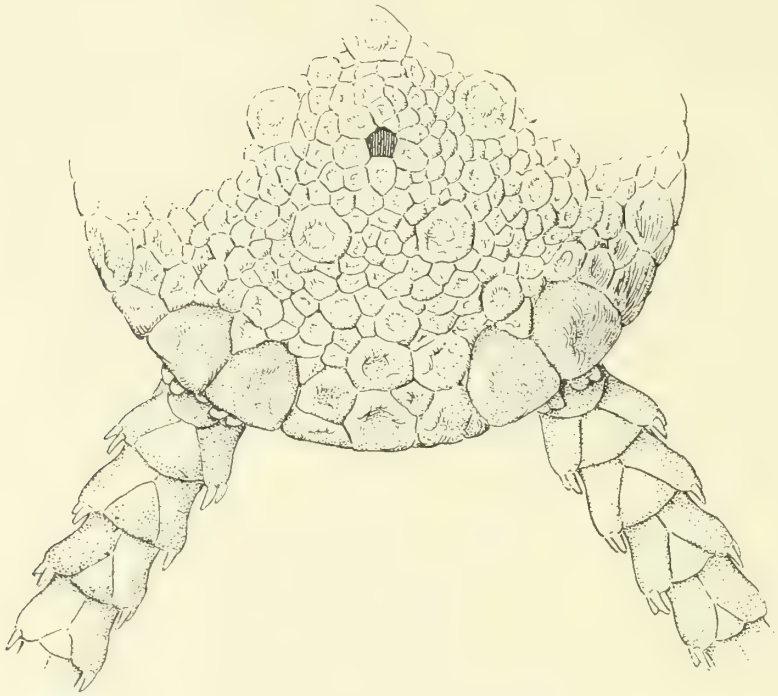
Locality.—Station 135 ; Maldive area ; 2727 metres. One specimen.

Description.—Disk flat, circular, rather more than 5 mm. across. Arms 5, a little flattened, but not much widened at base, tapering rapidly to a very slender tip ; the segments are much wider distally than proximally and become much elongated on the distal portion of the arm. Disk covered with numerous, small, thick, ill-defined porcelain-like plates ; each plate is more or less swollen or is thickened here and depressed there, so that the whole surface of the disk appears to be sculptured in a very irregular but pretty pattern. Even the radial shields, which are small and nearly circular, show indications of this sculpturing ; the two plates of each pair are broadly in contact, but are separated proximally by a small triangular plate. The centre of the disk is depressed, and where the primary central plate should be is an opening, as though the plate had been removed. But the surrounding plates are quite uninjured, and I cannot satisfy myself that this pore is artificial. The primary radial plates can be distinguished without difficulty, but they are some distance from the pore. Arm-comb greatly reduced ; 2–4 low thick papillæ may be detected below each radial shield. Upper arm-plates small, triangular, somewhat swollen ; the first is largest, and the size and swelling decreases steadily on the distal part of the arm, while the distance between the plates increases even more markedly.

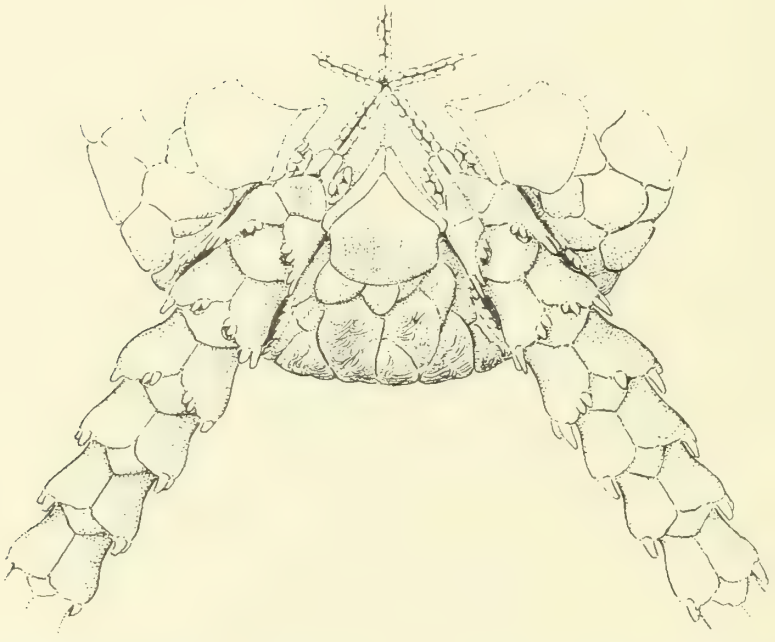
Interbrachial areas below covered by plates like those of the disk, but not quite so deeply sculptured. First under arm-plate rather large, pentagonal, its surface a little concave ; well separated from it is the second plate, similar but a little larger, more convex and with its lateral margins slightly indented by the tentacle-pores ; succeeding plates are more and more triangular, but much wider than long, and increasingly widely separated from each other. Side arm-plates large, forming the bulk of the arms. Each plate carried 3 (basally 4) short, thick, peg-like arm-spines placed very close together and appressed to the arm ; distally they are more slender and less appressed. Tentacle-pores reduced—in this specimen tightly closed ; oral pores with 3 low thick scales on each side ; first arm-pore with 2 on each side ; second and third pores with 2 on the side arm-plate ; no pores thereafter.

* γλυπτός = sculptured, in reference to the remarkable appearance of the disk.

TEXT-FIG. 51.



TEXT-FIG. 52.



TEXT-FIGS. 51, 52.—*Homalophiura glypta* sp. nov. FIG. 51.—Dorsal view of half of disk and two arm-bases. × 16. FIG. 52.—Oral view of same. × 16.

Oral shields relatively large, wider than long, pentagonal, with a conspicuous inner angle, short lateral margins and a more or less strongly convex distal side. Adoral plates narrow, lying along the sides of the oral plate's angle and meeting fully within. Oral plates shorter and wider, scarcely at all swollen. Oral papillæ so low, thick and close-set that they completely close the oral slits, and it is difficult to make out the number and form; apparently there are 5 or 6 on each side, with the distal ones widest and the unpaired proximal one narrowest. Colour, of dry specimen, pure lustrous white, like porcelain.

Remarks.—This lovely little ophiuran is so well characterized by its sculptured porcelain-like disk that it will be readily recognized if it is again taken. It is not at all nearly related to "*Ophiura glyptodisca*" (= *Aspidophiura forbesi* Duncan) which I described from Japan in 1911 ; a shallow-water species in which the so-called sculpturing is of a totally different character. It is quite improbable that the pore in the centre of the disk in the unique holotype of *glypta* is a normal feature, as nothing of the kind is known among ophiurans.

ANOPHIURA* gen. nov.

Ophiolepids with very flat, thin disk bounded by the 10 radial shields and 5 large interradial marginals. Arms slender with very small upper and under arm-plates. Arm-comb wanting. Oral shields, adoral plates and oral plates large, covering a considerable part of the oral surface. Oral papillæ very low and wide, quadrilateral. Only 3 pairs of tentacle-pores on arm, the first with two low wide scales on each side, the other two each with a single circular scale.

Genotype : *Anophiura simplex* sp. nov. (*vide infra*).

The two species here segregated in a new genus represent the extreme development of the group called Homalophiura. The complete absence of an arm-comb, the very definite pattern of disk plating and the extreme reduction of tentacle-pores and scales warrant their generic separation. They are small, very flat, rather fragile brittle-stars, taken as yet only along the southern coast of Arabia in depths exceeding a thousand metres.

Anophiura planissima† sp. nov. (Text-figs. 53 and 54).

Localities :

Station 33 ; Gulf of Aden ; 1295 metres. One specimen.

Station 193 ; Gulf of Aden ; 1061–1080 metres. One specimen.

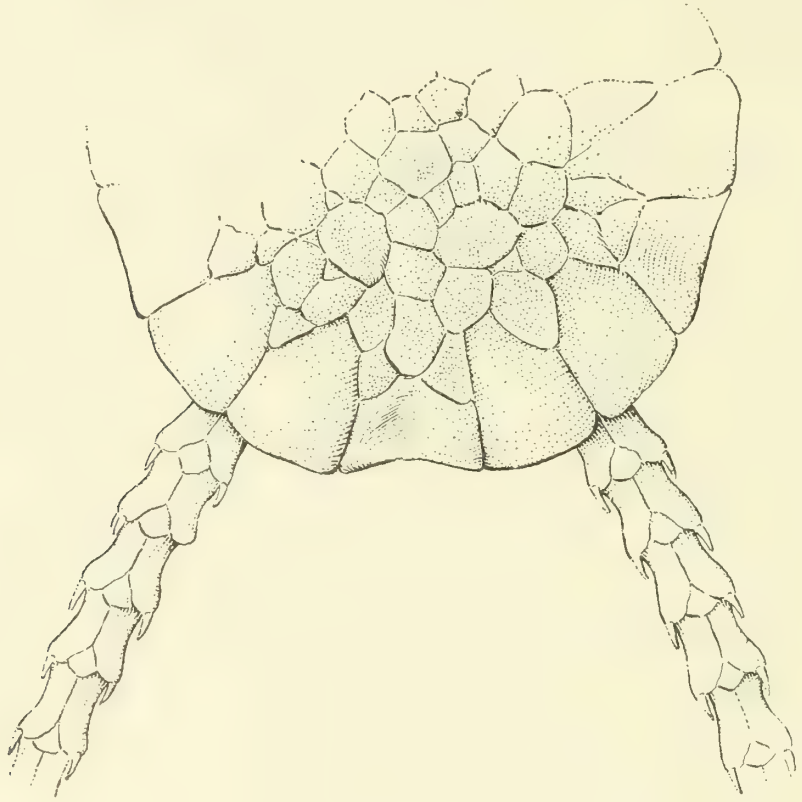
Description.—Disk very flat, thin and smooth, nearly circular, 6 mm. in diameter. Arms 5, all but one are missing ; of that one 11 segments, totalling 7 mm. are present ; the segments are more or less elongated and are wider distally than proximally ; it is evident the arms in life are about 2·5 times the disk diameter, very slender and nearly cylindrical, but a little flattened basally. Disk covered by the 10 big radial shields, and 5 interradial marginals and about 60 other thin, flat scales, among which the primary plates are not conspicuous. All the plates are very smooth and shining like porcelain. Radial shields somewhat triangular, longer than wide, broadly in contact distally, but separated proximally by a large wedge-shaped scale. There is no arm-comb. Upper arm-plates very small and widely separated ; first largest, triangular, slightly swollen, longer than

* ἄν privative + *ophiura*, in reference to its relation to, but lack of identity with, Ophiura.

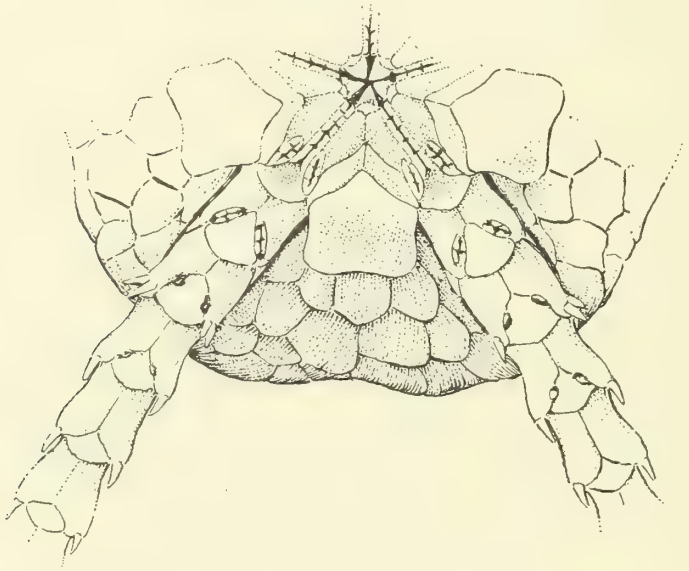
† *planissimus* = most flat, in reference to the extremely depressed form.

wide; second plate similar but shorter; succeeding plates wider than long and very insignificant.

Text-fig. 53.



Text-fig. 54.



Text-figs. 53, 54.—*Anophiura planissima* sp. nov. Fig. 53.—Dorsal view of half of disk and two arm-bases. × 14. Fig. 54.—Oral view of same. × 14.

Interbrachial areas below covered by the large oral shields and a number of plates like those of the disk. Genital plates relatively large with a smooth margin. Under

arm-plates widely separated ; first relatively large, somewhat triangular ; second a bit larger and more pentagonal, its lateral margins indented by the tentacle-pore ; third plate much wider than long with a convex distal margin and a proximal angle ; succeeding plates similar, but smaller and swollen. Side arm-plates very large, forming the bulk of the arm ; they are smooth and shining like porcelain. Each one carries 3 minute, acute, appressed arm-spines, scarcely one -third as long as the segment. Tentacle-pores extremely reduced ; the oral pore is relatively large, with 3 low, wide, rounded scales more or less soldered together on each side. First arm-pore similar but smaller, with 2 (or 1 only) scales on each side. Second and third pores minute, protected by a single small circular scale. No subsequent pores.

Oral shields relatively large, pentagonal, wider than long, or length and breadth about equal ; there is an acute inner angle, but the other angles are rounded ; distal margin straight or slightly concave. Adoral plates large, lying along the inner sides of the oral shield and meeting broadly within ; their width is about one-third of the length. Oral plates very large and distinct, bigger than the adorals, curved upward (seen with animal upside down, of course) and slightly swollen at proximal ends. Oral papillæ 3 or 4 on each side, very low and wide, quadrangular, close set, the outermost widest ; unpaired terminal papilla flat and triangular.

Colour of dry specimen very pale pearl grey, becoming white orally and on arms, smooth and shining like porcelain.

Remarks.—The holotype is from Station 193. The paratype is much smaller, only 3 mm. across the disk. All of the arms are present in some degree, and the longer ones indicate that when complete they were four times the disk diameter. There are, of course, fewer plates on the disk, and the 6 central primary plates are conspicuous. The porcelain-like appearance is fully as marked as in the larger specimen. The nearest relative of this interesting brittle-star is no doubt the following species, but probably some of the small species of Homalophiura will be found to be more or less closely allied.

Anophiura simplex* sp. nov. (Text-figs. 55 and 56.)

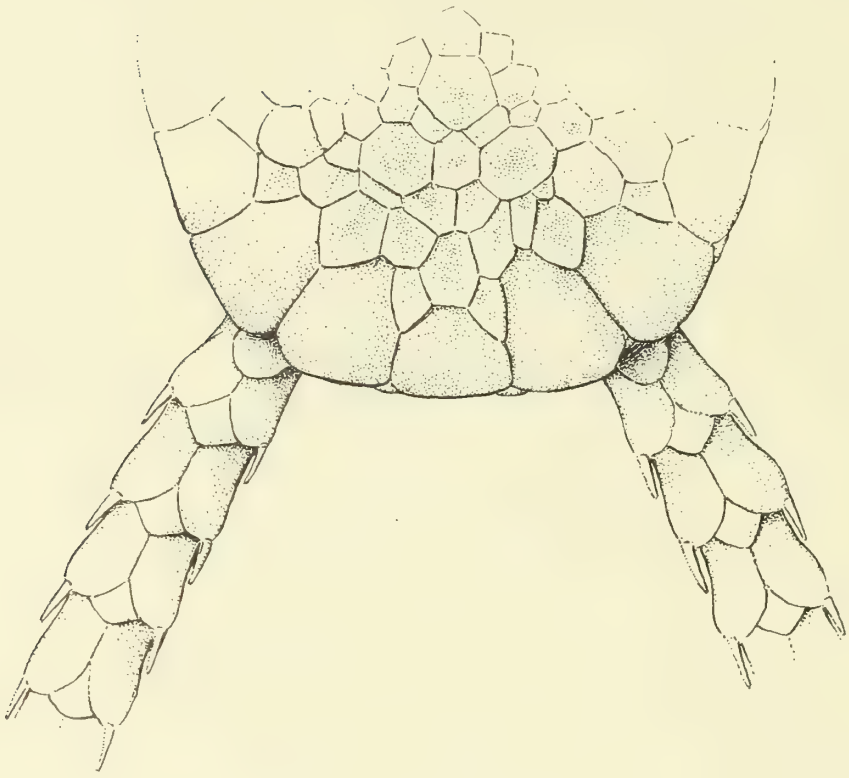
Locality.—Station 54 ; South Arabian coast ; 1046 metres. One specimen.

Description.—Disk very flat and thin, rounded pentagonal, not quite 5 mm. in diameter. Arms 5, all broken, so the approximate length can only be guessed at, but it is obvious that the arms are thicker and the segments shorter than in the preceding species. Disk covered by about 50 plates in addition to the 10 radial shields and the 5 interradial marginals ; central primary plate and the 5 radials are quite conspicuous. The plates are all smooth, but very minutely porous, not at all like porcelain. Radial shields about as wide as long, rounded triangular, broadly in contact but separated proximally by an elongated pentagonal scale. The disk slightly overhangs the arm-bases, but there is no trace of an arm-comb. Upper arm-plates very small and widely separated ; the basal ones are triangular with a convex distal margin, about as long as wide, but further out they are wider than long.

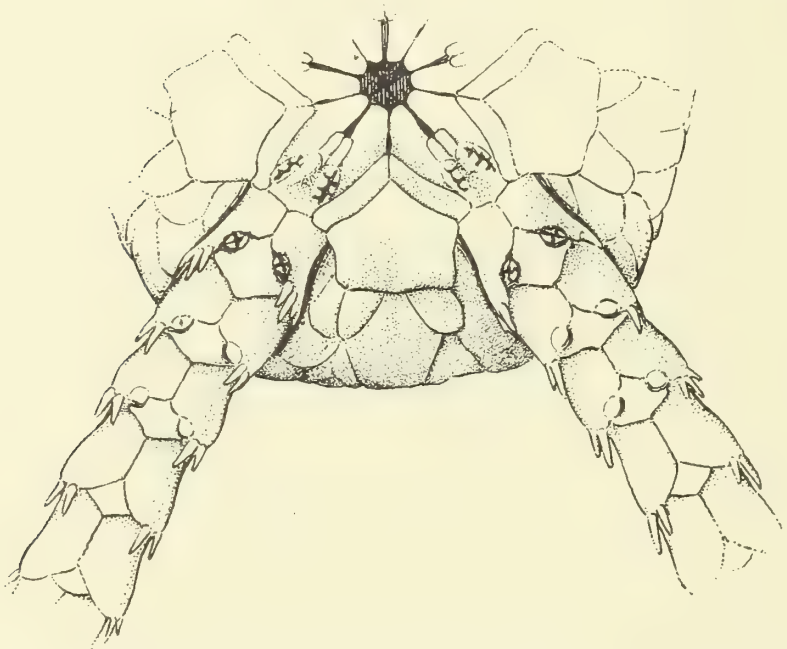
Interbrachial areas below covered by a few plates like those of the disk, and the big oral shield. Under arm-plates widely separated ; the first is relatively very large, more or less triangular and longer than wide ; the second is similar but more pentagonal, larger,

* *simplex* = simple, in reference to the small number of plates in its make-up.

TEXT-FIG. 55.



TEXT-FIG. 56.



TEXT-FIGS. 55, 56.—*Anophiura simplex* sp. nov. FIG. 55.—Dorsal view of half of disk and two arm-bases. × 14. FIG. 56.—Oral view of same. × 14.

with convex distal margin and concave or slightly notched distal lateral margins ; third plate is hexagonal, much wider than long, with deeply notched distal lateral margins ; succeeding plates smaller and similar, but beyond the fifth the plates are much smaller and more triangular, always wider than long. Side arm-plates rather short and stout, making up the bulk of the arm ; probably distally the segments are more elongated than any now present. Arm-spines 3, minute, the uppermost longest, but not a third of the length of the segment, slender and pointed ; they are evidently easily knocked off, for most of the side arm-plates carry only one or two. Tentacle-pores and scales as in the preceding species, only the scales are not at all porcelain-like ; oral pore and first arm-pore elongated, with 3 or 2 scales on each side ; other pores small, with a single rounded scale.

Oral shields distinctly wider than long, pentagonal, with a rather wide inner angle and a straight distal margin. Adoral and oral plates large and wide, as in the preceding species. Excepting the widest distal ones, the oral papillæ are all wanting, having been knocked off in the rough journey in the dredge, probably ; they were, no doubt, like those of *planissima*.

Colour of dry specimen pale grey with a tinge of brown on the outer ends of the radial shields ; the upper arm-plates and much of the oral frame more nearly white.

Remarks.—This species is obviously near the preceding in all details of structure, but the texture of all the plates is so different, they do not look much alike. Moreover, the arm-segments are shorter and thicker in *simplex*, and the first 3 or 4 under arm-plates are markedly different in the two species. It is interesting that their bathymetrical range is the same. Possibly the geographical ranges do not overlap, but that is hardly probable.

Ophiomusium altum Koehler.

Ophiomusium altum Koehler, 1904, p. 57 ; pl. 10, figs. 2–4.

Localities :

Station 26 ; Gulf of Aden ; 2312 metres. One specimen.

Station 118 ; Zanzibar area ; 1789 metres. Three specimens.

Range.—East Indies, Strait of Makassar, 1648–2029 metres.

Notes.—These specimens are a little larger than the two previously known (" Investigator " and "Albatross " collections) having the disk diameter 5–7 mm., but unfortunately they are in poor condition, the outlines of the plates being obscured by a kind of thick membrane, probably an artefact, and the arms are all broken.

Remarks.—In spite of the difficulty of making out the plates, I have no hesitation in referring these specimens to Koehler's East Indian species. The elevation of the disk in the two larger specimens and the number and character of the arm-spines are good distinguishing features, and so far as the outlines of the plates can be made out, they correspond fairly well to the photographs given by Koehler in 1922 (pl. 80, figs. 6, 7 and 12).

Ophiomusium cancellatum Lyman.

Ophiomusium cancellatum Lyman, 1878, p. 111 ; pl. 1, figs. 17 and 18.

Locality.—Station 119 ; Zanzibar area ; 1207–1463 metres. Seventeen specimens.

Range.—Eastern Japan, 117–1814 metres. Lyman's record, from Bermuda, is given with a question mark and lacks confirmation.

Notes.—These specimens, which range in disk diameter from 7 to 14 mm., have been

compared with Japanese material and the differences are so insignificant that their identity seems assured. They are pale greyish white in colour, and the arms are about 3 times the disk diameter.

Remarks.—It is rather extraordinary to discover this Japanese species off the coast of Zanzibar, since neither the "Investigator" nor "Siboga", "Valdivia" nor "Albatross", found it either in Indian waters or in the East Indies.

Ophiomusium elegans Koehler.

Ophiomusium elegans Koehler, 1897, p. 305 ; 1922, pl. 88, figs. 1–9.

Localities :

Station 33 ; Gulf of Aden ; 1295 metres. One specimen.
Station 143 ; Maldive area ; 797 metres. Three specimens.
Station 145 ; Maldive area ; 494 metres. Ten specimens.

Range.—East Indies to Laccadive Islands, 400–2021 metres.

Notes.—The specimen from Station 33 is so small, only 4 mm. across the disk, that its identity is open to question, but those from the Maldive area are undoubtedly *elegans*. They range from 9 to 17 mm. in diameter and correspond well with Koehler's (1922) account and figures of the "Albatross" material.

Remarks.—The discovery of this species in the Maldive area is quite in keeping with its occurrence at the Laccadives. That the range extends to the Gulf of Aden is quite likely, but the specimen from Station 33 is too young to prove it.

Ophiomusium familiare Koehler.

Ophiomusium familiare Koehler, 1897, p. 303 ; pl. 6, figs. 20 and 21.

Localities :

Station 108 ; Zanzibar area ; 786 metres. One specimen.
Station 109 ; Zanzibar area ; 640 metres. Six specimens.
Station 110 ; Zanzibar area ; 347–384 metres. One specimen.
Station 115 ; Zanzibar area ; 640–658 metres. One hundred and thirty-seven specimens.
Station unknown. Two specimens.

Range.—Kei Islands, East Indies to the Malabar coast and Maldive Islands, 250–1382 metres.

Notes.—This is a very fine lot of a little-known species, with disks ranging from 7 to 22 mm. across. The arms are almost always broken near the tip, but are just about three times as long as the disk diameter, in the smallest as well as in the largest specimen. The diversity of colour is rather striking. Several specimens are almost uniformly white, one (from Station 110) is yellowish and several (from Station 115) are dull, dusky purplish grey. The remainder are intermediate between the white and the deep grey ones ; the arms, clear to the mouth may be deep grey, with the disk, including interbrachial areas below, much lighter. Or the disk may be white with the arms gradually becoming grey, or the whole animal may be a light purplish brown. In many cases the tips of the arms, especially if recently regenerated, are white, in marked contrast with the basal portion. Occasionally the transition from white tip to dark proximal segments is not abrupt but very gradual.

It would be interesting to have colour notes on the appearance of these brittle-stars in life. Alcoholic specimens are naturally more brightly coloured, and the contrasts between the light and dark shades are often very handsome. The brown of the arms may be very dark, approaching black in some cases.

Remarks.—A specimen of *familiare* from the "Investigator" collections, from the Andaman Islands, sent to the Museum of Comparative Zoölogy by the Indian Museum has been compared with this material from Zanzibar and validates the identification. The extension of range geographically is considerable, but there is none bathymetrically.

Ophiomusium lütkeni Lyman.

Ophiomusium lütkeni Lyman, 1878, p. 114; pl. 5, figs. 138–140.

Localities:

Station 105; Zanzibar area; 238–293 metres. Ten specimens.

Station 106; Zanzibar area; 183–194 metres. One hundred and forty-four specimens.

Range.—Japan to the Kei Islands, 196–274 metres.

Notes.—This is a fine series of a well-marked species, as the specimens range from 4 to 10 mm. in disk diameters. The arms are notably short, for in no case are they equal to twice the width of the disk. They are without exception broken, but usually it is obvious that only the most attenuate terminal joints are missing. The colour is nearly white.

Remarks.—These specimens have been compared with a co-type of *lütkeni* from the Kei Islands and with specimens from Japan. There is notable agreement in all respects except the length of arms. In Lyman's specimen (which is 14 mm. across) the arms are about 3 times disk diameter and in those from Japan (10–13 mm. across) they are about 2·5 times, but in these Zanzibar specimens they could scarcely have been, even in life, more than twice the width of the disk. If this peculiarity of East African specimens should prove to be constant, a varietal name might be useful.

Ophiomusium validum Ljungman.

Ophiomusium validum Ljungman, 1871, p. 618. Lyman, 1882, pl. 1, figs. 1–3.

Localities:

Station 107; Zanzibar area; 421–457 metres. Two specimens.

Station 115; Zanzibar area; 640–658 metres. One hundred and thirty-two specimens.

Range.—West Indies, East Indies, Laccadive Islands, 108–2732 metres.

Notes.—The two specimens from Station 107 are obviously young, 4·5 and 8 mm. across the disk, but those from Station 115 are fine adults, 11–22 mm. in disk diameter. The largest previously reported were 12–13 mm. across. The smallest specimen at hand has one arm practically complete, and it measures less than 12 mm., or rather less than 3 times the disk diameter. An adult, 17 mm. across the disk has one arm over 60 mm. long, with the terminal segments missing; in this specimen therefore the arms were about 4 times the disk diameter, and this is apparently the usual proportion for the species. In the largest specimen (22 mm.) the arms are all broken, but enough of one is present to warrant an estimate of close to 90 mm. for its length; diameter at base 5 mm., at 45 mm. from base a little more than 2 mm.; the tapering of the arms is therefore quite abrupt.

Compared with large West Indian specimens (not hitherto described or discussed) the scaling of the disk is firmer and smoother in those from Zanzibar, and the arm-spines are smaller and more irregular.

Remarks.—Koehler (1897) first reported *validum* from the Indian Ocean and a few years later (1905) recorded the " Siboga's " discovery of it in the East Indies. He has discussed some of the diversity shown by his specimens, but he apparently did not note a curious error made by Lyman, who says (1878, p. 114 ; 1882, p. 92), " No under arm-plates beyond the third ". This is true only of young individuals ; in the youngest at hand there are no plates visible except the basal three, and in the specimen 8 mm. across on four arms there are no other plates, but on one arm 4 or 5 rudimentary plates can be made out on the proximal segments. In larger specimens under arm-plates can be easily seen on the proximal half of the arm ; in the largest specimen at least 25 are present on each arm. It is true they are small, particularly the more distal ones, but they are undoubtedly present. This is as true of West Indian specimens as of those from Zanzibar. As Ljungman says (1871, p. 619) in his original description of the " scutella brachiorum ventralia ", after discussing the first three, " longius ab ore rudimentaria ", it is strange that Mr. Lyman should have made this slip.

Ophiomusium breve sp.* nov. (Text-figs. 57 and 58.)

Locality.—Station 105 ; Zanzibar area ; 238–293 metres. Three specimens.

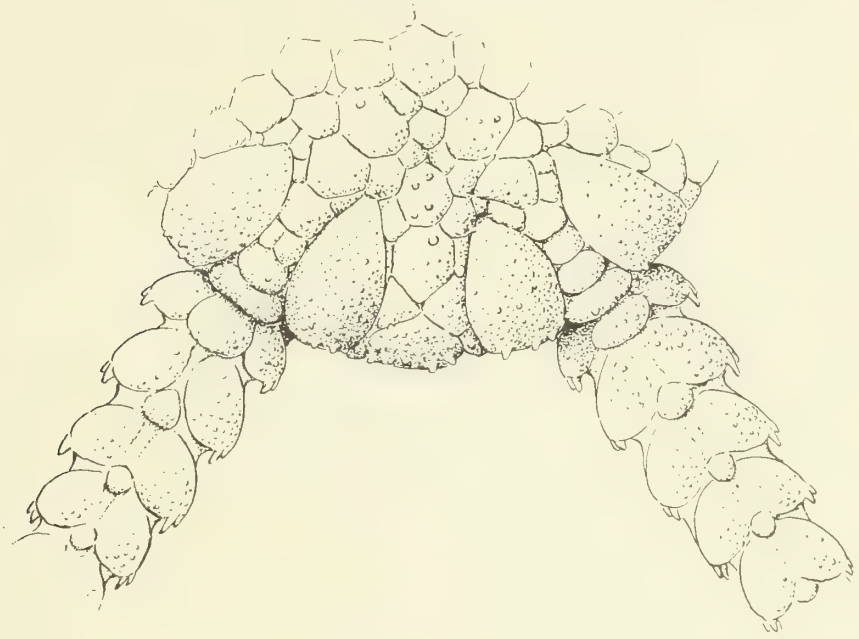
Description.—Disk very slightly elevated but not convex, 6 mm. in diameter. Arms 5, fairly wide at base but tapering rapidly to an attenuate tip, about 12 mm. long, or twice the disk diameter. Disk covered with about 100 scales with a finely shagreened surface ; the primary plates and radial shields, with two or three others, arranged in diverging series in each radius and interradius, form most of the covering however. Radial shields triangular (with rounded angles) widely separated both radially and interradially, about 1·30 mm. long, with the distal end about 1 mm. wide. Upper arm-plates small but persistent to the middle of the arm ; the first is elliptical, twice as wide as long, distinctly swollen and crowded against the similar but larger distalmost radial plate ; succeeding plates much smaller, rounded triangular or circular, more or less swollen, or at least convex.

Interbrachial areas below covered by about a dozen scales between the large genital plates ; 3 scales are marginal in position and bear on their distal edge 3–5 small, conical granules. These granules are distinctly visible from above and form an irregular but more or less continuous series around the disk, as similar but somewhat smaller ones occur on the arm-bases, at the upper end of the genital plates. Proximal to the 3 marginal scales in each interradius is a large scale with a smaller one on each side ; between it and the oral shield is another large scale and several small ones, but their number, size and position are diverse. Genital slits long, with finely notched margins. Under arm-plates present on proximal half of arm ; the first 3 are relatively large, more or less pentagonal, but longer than wide, with concave margins, slightly convex with a shagreened surface ; succeeding plates rounded triangular, wider than long at first, but becoming rapidly smaller and smaller and more nearly circular, until they disappear. Side arm-plates large and solid as usual in the genus, the distal ends much wider and more swollen than the proximal, the surface strongly shagreened. Each carries 3 (4 or 2) thick but pointed

* *brevis* = short, in reference to the notably short arms.

arm-spines, about one-fourth as long as the plate itself. Tentacle-pores 3 on each side, each one protected by a relatively large, convex scale on the outer side and a similar but smaller one on the inner.

Text-fig. 57.



Text-fig. 58.

Text-figs. 57, 58.—*Ophiomusium breve* sp. nov. Fig. 57.—Dorsal view of part of disk and two arm-bases. × 14. Fig. 58.—Oral view of same. × 14.

Oral shields small, much longer than wide, sharply pointed within, but with a rounded-truncate distal end. Adoral plates nearly as large, their pointed inner ends meeting at the tip of the oral shield. Jaws short and wide, the 3–5 oral papillæ low and ill-defined, but the outermost is widest. Colour (dry) nearly white, but the radial shields and larger disk-scales are a trifle more greyish.

Remarks.—Of the two paratypes one is only 3 mm. across the disk, but the other is

as large as the one described. They show no points of difference which call for comment. The species itself seems quite distinct from any previously known, and will be easily recognized by the character of the disk scaling, the fringe of marginal granules, the small oral shields, the swollen side arm-plates, with strongly shagreened or granular surface, and the few, tiny arm-spines.

Ophiomusium nitidum* sp. nov. (Text-figs. 59 and 60.)

Locality.—Station 171 ; central part of the Arabian Sea ; 3840–3872 metres. Four specimens.

Description.—Disk more or less elevated, almost 7 mm. across. Arms 5, somewhat slender and stiff, rather more than 20 mm. long, though the tips are missing. Disk covered with about 60–65 plates, of which the radial shields are largest, but the 5 primary plates and a large marginal plate in each interradius are very conspicuous. The central plate is notably smaller than the radials. A triangular plate separates the inner ends of the radial shields and another nearly or quite as large separates their distal ends. All of these larger plates (except the radial shields) are markedly convex, and have a shagreen-like surface, as do the radial shields. When viewed without magnification, however, the surface seems more or less glazed and shining. Radial shields irregularly pentagonal, longer than wide, the interradial side slightly concave (because of the large interradial plate) the outer end truncate with rounded corners ; they are in contact at only one point near the middle of the radial side. Upper arm-plates small and widely separated, disappearing distal to the middle of the arm ; the first is somewhat crescentic, with blunt ends, and adjoins the distal radial plate very closely. Succeeding plates more or less triangular, with rounded corners, longer than wide at first, but when very small the length and breadth are about equal.

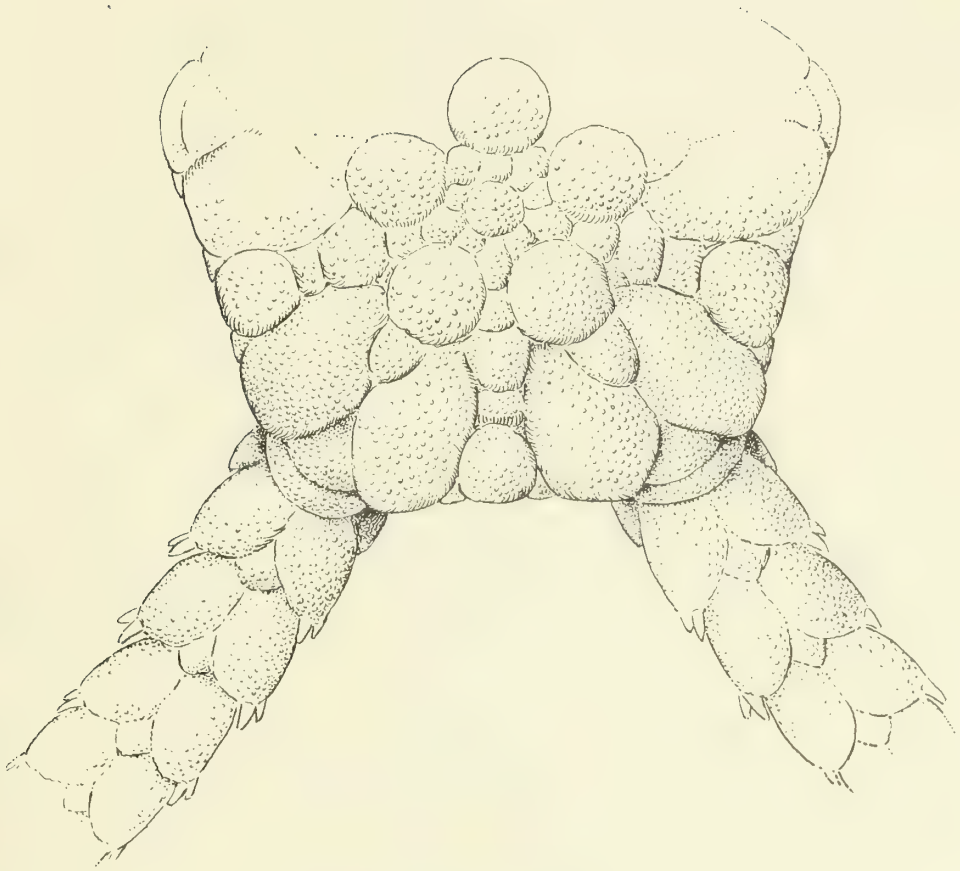
Interbrachial areas below covered by 5–8 small convex plates, but the oral frame is large and the oral shields extend fully halfway to margin. Genital slits seem to be wanting. The whole oral surface is covered by more or less of a membrane, which is probably an artefact, but which conceals to some extent the plate outlines. About a dozen under arm-plates are present, but only the first three are worthy of note ; they are somewhat pentagonal, a little longer than wide, with concave lateral margins, slightly separated from each other ; the remaining plates are minute triangles widely separated and soon disappearing. Side arm-plates large, longer than wide, not swollen ; distal ends project but little, so the arms are flattened cylinders, but regularly notched and tapering. Arm-spines 3, subequal, bluntly pointed, very small, about one-fourth as long as the arm-segment, or less. Tentacle-pores 3 on each side of the arm-base, very small, covered by a single minute tentacle scale on the outer side of the pore ; rudiments of a second scale may be detected on the inner side.

Oral shields longer than wide; pointed within, rounded without, slightly swollen ; adoral plates similar but a trifle larger, even more swollen and conspicuously shagreened. Jaws short and wide. Oral papillæ 5 on each side, low and wide, their outlines indistinct, but the outermost widest. Colour (dry) shining pearly white.

Remarks.—In most particulars this species is very similar to the West Indian species *serratum*, but when specimens of the same size are placed side by side, they look quite

* *nitidus* = shining, in reference to the glazed, shining appearance.

Text-fig. 59.



Text-fig. 60.

Text-figs. 59, 60.—*Ophiomusium nitidum* sp. nov. Fig. 59.—Dorsal view of most of disk and two arm-bases. × 12. Fig. 60.—Oral view of same. × 12.

different. The West Indian species is flatter and smoother, the plates are not at all swollen, lack the coarse shagreen surface and the sheen, and the genital slits are very evident. Of course, more abundant material from the Arabian Sea or Indian Ocean may show that these differences are not constant and have no real value, but for the present it seems wiser not to record the West Indian species from the Arabian Sea.

The paratypes of *nitidum* range from 3 to 5 mm. across the disk ; the arms are not quite three times as much. The coarsely shagreened surface and the sheen are evident in all, and there is no trace of genital slits. They are apparently not the young of any species as yet described, but it is, of course, quite possible that not even the holotype is adult.

Ophiomusa lymani (Wyville Thomson).

Ophiomusium lymani Wyville Thomson, 1873, p. 172.
Ophiomusa lymani Hertz, 1927, p. 103.

Localities :

Station 26 ; Gulf of Aden ; 2312 metres. Eighteen specimens.
Station 62 ; northern area of Arabian Sea ; 1893 metres. Three specimens.
Station 118 ; Zanzibar area ; 1789 metres. Thirty-one specimens.
Station 119 ; Zanzibar area ; 1207–1463 metres. One specimen.
Station 155 ; Maldive area ; 2249 metres. One specimen.
Station 185 ; Gulf of Aden ; 2000 metres. Two hundred and six specimens.

Range.—Almost cosmopolitan in deep water, 126–3435 metres.

Notes.—This is an interesting lot of a common deep-sea ophiuran, some of the individuals being the largest as yet recorded. The series from Station 185 is particularly notable, as the specimens range from less than 3 mm. across the disk to 48 mm. The largest specimens of *lymani* hitherto recorded were only 35 mm. in disk diameter, so these Gulf of Aden specimens are indeed huge.

Remarks.—The large specimens at hand confirm Koehler's (1922, p. 413) statement that the number of arm-spines in *lymani* increases with age, and big adults have as many as a dozen, and not merely the 6–8 usually given as the species character. Moreover the spines when so numerous form a very irregularly-spaced series, rather widely separated at the upper end and irregularly grouped near the ventral surface of the arm ; the lowest are noticeably the longest.

Ophiomusa ultima Hertz.

Ophiomusa ultima Hertz, 1927, p. 106 ; pl. 9, figs. 1–3.

Locality.—Station 105 ; Zanzibar area ; 238–293 metres. Five specimens.

Range.—East and north of Zanzibar, 400–638 metres.

Notes.—These specimens are all small, 2–4 mm. across the disk, but they seem to be quite typical. Not one shows any genital slits, as was the case with the specimens figured in the original description of the species.

Remarks.—The rediscovery of one of the " Valdivia's " species is interesting but does not extend its range geographically. Bathymetrically the range is brought into somewhat shallower water.

Ophiozonella molesta (Koehler).

Ophiozona molesta Koehler, 1904, p. 22 ; pl. vi, figs. 3–5.
Ophiozonella molesta Matsumoto, 1915, p. 82.

Locality.—Station 42 ; South Arabian coast ; 1415 metres. One specimen.

Range.—East Indian region from Hong-Kong to the Kei Islands, in 68–1270 metres.

Notes.—This interesting specimen is 13 mm. across the disk and hence is a little larger than the biggest one hitherto known. The number of disk-scales is much greater than in the holotype, and hence the appearance of this adult is quite different from Koehler's original figures, but fairly like his later photographs (1922, pl. 78, figs. 3 and 4). The colour of the disk is pale grey, but the arms are more nearly white.

Remarks.—The extension of range made by taking this large adult specimen of *molesta* on the South Arabian coast is indeed notable, since neither the " Investigator " nor the " Valdivia " had secured it in the central and western Indian Ocean. Koehler (1922, p. 428) thinks his species recalls *tessellata* Lyman, but says " the radial shields are smaller and they do not possess the large broadened and short spine on their distal border in *tessellata* ". Obviously he means to say the short, thick spine on their distal border *as* in *tessellata*. This short, thick spine is a conspicuous feature of Lyman's West Indian species, but both Lyman and Koehler err in saying it is borne on the outer end of the radial shield. It is borne either on the upper end of the genital scale or more commonly on a small disk-scale distal to the radial shield. It is not always present, but in almost every specimen is to be found in one or more of the radii. On the whole, it does not seem to me that the resemblance or relationship of *molesta* to *tessellata* is very close.

Ophiozonella brachyactis* sp. nov. (Text-figs. 61 and 62.)

Localities :

Station 26 ; Gulf of Aden ; 2312 metres. Two specimens.
Station 185 ; Gulf of Aden ; 2000 metres. Two specimens.

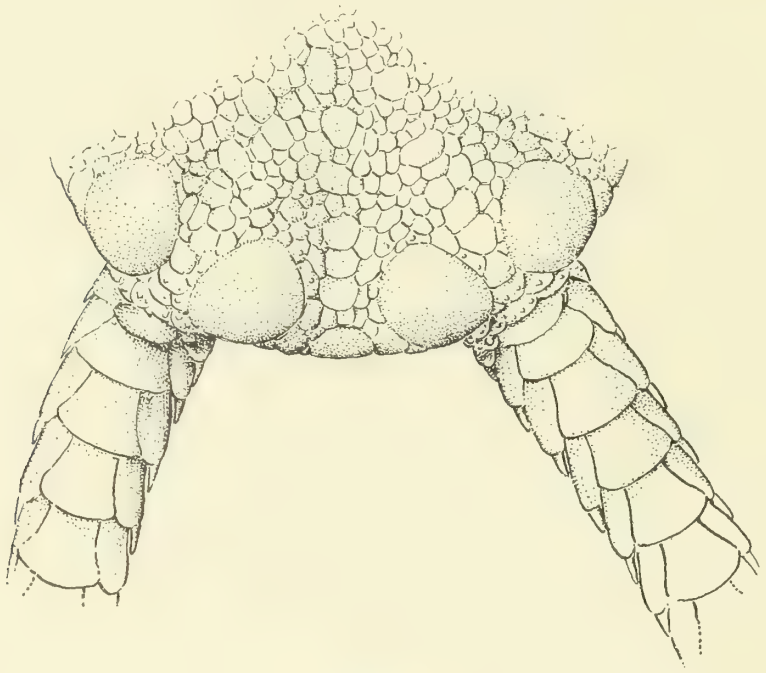
Description.—Disk quite flat, nearly circular, 10 mm. across. Arms 5, stout and nearly cylindrical at base, but tapering rapidly and becoming more flattened distally, not quite 30 mm. long. Disk covered by a close coat of numerous, rather small, slightly swollen scales, among which the primary plates cannot be clearly distinguished, but a large marginal plate occupies most of the interradial edge of the disk between the pairs of radial shields. The latter are about as broad as long, irregularly rounded pentagonal or hexagonal ; the two of each pair are widely separated from each other by a group of 6–8 disk-scales of diverse size. Distal to each radial shield are a few minute granules irregularly placed on the disk margin or upper arm-plates ; there is no clearly defined boundary between the disk margin and the base of the arm. Radial shields and larger disk-scales not smooth and shining, but very finely shagreened. First upper arm-plate very short and wide, with rounded ends, the width nearly three times the length ; second plate more nearly quadrilateral, about twice as wide as long, the distal side a little wider than proximal ; third plate with length and breadth more nearly equal and distal margin much longer than proximal ; succeeding plates at first similar, but soon becoming longer than

* βραχύς = short + ἀκτίς = ray, in reference to the short arms.

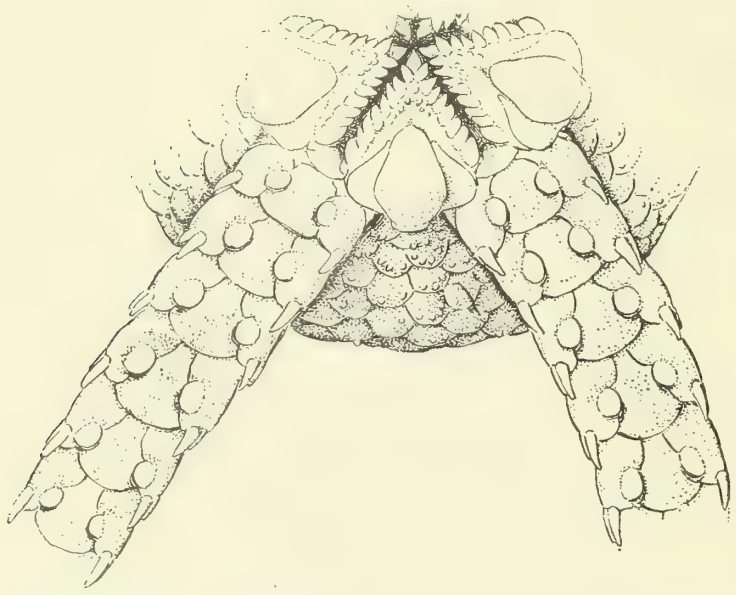
wide and more nearly triangular, until distally, where they cease to be in contact with each other, they are small triangles, increasingly separated by the side arm-plate.

Interbrachial areas below covered with small scales like those of the disk; on the

TEXT-FIG. 61.



TEXT-FIG. 62.



TEXT-FIGS. 61, 62.—*Ophiozonella brachyactis* sp. nov. FIG. 61.—Dorsal view of part of disk and of two arm-bases. × 8. FIG. 62.—Oral view of same. × 8.

borders of these scales are scattered minute granules similar to those on the radial disk margins. These granules tend to outline the scales, but they are rarely numerous enough to completely encircle even one scale. First under arm-plate of moderate size, triangular, with convex distal margin, a trifle wider than long; second plate axe-head-shape, the

distal margin convex and wide, the proximal short, straight and fully in contact with first plate, the lateral curved around the tentacle-pores to reach the long distal margin ; succeeding plates have the proximal margin shorter and shorter until, beyond the middle of the arm, it is a sharp angle and no longer touches the preceding plate ; at the same time the plates, decreasing rapidly in size become more and more nearly triangular, and the big side arm-plates which are wider distally than proximally make up nearly the whole arm. Each plate carries near its lower margin 2 thick, peg-like, bluntly pointed arm-spines which are about one-third as long as the side arm-plates, or a little more. Tentacle-pores rather large basally, continuous to tip of arm, protected by a single large circular tentacle scale, which, near the base of the arm, is fully half a millimetre across.

Oral shields large, pear-shaped, longer than wide, the inner end rounded and distinctly narrower than the outer. Adoral plates small, ill-defined, more or less triangular and lying near widest part of oral shield, separating it from first side-arm plate. Oral plates small, more or less concealed by a number of minute granules, like those on the interbrachial area. Oral papillæ 7 (6–8) on each side, the inner ones small and pointed, the outer ones wider and truncate, the outermost largest, as wide as high or wider, with corners rounded.

Colour of dry specimens very pale grey ; the specimens from Station 185 have a definitely yellowish cast, but those from Station 26 show no trace of yellow, and have the arms almost pure white.

Remarks.—This deep-water Ophiozonella from the eastern end of the Gulf of Aden is well set off from the other members of the genus by the large single tentacle-scales, the short, thick arm-spines in pairs, the peculiar shape of the oral shields, and the minute granules on oral plates and interbrachial areas, extending to the dorsal surface of the arm-bases.

The holotype is from Station 185 and the paratype from that station deserves a word. It is apparently tetramerous, but not symmetrically so. The disk is 9 mm. by 8 mm., and the arms are 27 mm. Many arm-segments have 3 arm-spines. There are but 4 jaws, but one of them is badly deformed on one side, and it is possible that the accidental loss of the fifth arm in early youth accounts for this deformity and the present tetramerous condition. The specimens from Station 26 are 7 mm. and 9 mm. across the disk, which is rather convex, but otherwise is not peculiar.

Family **OPHIOLEUCIDÆ.**

Ophiocirce inutilis Koehler.

Ophiocirce inutilis Koehler, 1904, p. 13 ; pl. 3, figs. 4 and 5.

Localities :

Station 106 ; Zanzibar area ; 183–194 metres. Fifty-three specimens.

Station 111 ; Zanzibar area ; 73–165 metres. One specimen.

Station 208 ; Red Sea ; 732–805 metres. Two specimens.

Range.—Known only from Dutch East Indies, south of Buru, 112 metres, and Philippine Islands between Leyte and Masbate, 209 metres.

Notes.—The specimen from Station 111 is a particulaly fine one, a full 10 mm.

across the disk, and thus much larger than any of Koehler's specimens. The smallest of the present series is 6 mm. in disk diameter, only a little smaller than Koehler's type. The Zanzibar specimens are all nearly pure white, but the two from the Red Sea are a little dingy. In structure, however, they are not distinguishable and one can but wonder as to the possibility of a mistake in the label. Not only is the locality far away from the areas where Ophiocirce is known to occur, but the depth is three or four times that at which specimens have otherwise been taken. In any case the discovery of Ophiocirce by the " Mabahiss " in the western Indian Ocean is a very notable extension of range.

Ophiocrates secunda Koehler.

Ophiocrates secunda Koehler, 1906, p. 14 ; pl. 1, figs. 13 and 14.

Localities :

Station 34 ; Gulf of Aden ; 1022 metres. One specimen.

Station 158 ; Maldive area ; 786–1170 metres. Two specimens.

Range.—West Africa, off Rio de Oro, 2325–2640 metres.

Notes.—The specimen from the Gulf of Aden is only 5 mm. across the disk, and hence is too small for positive identification, but one of the two from the Maldives is no larger and its identity is determined by the other specimen, which is almost 8 mm. in disk diameter, with arms 24 mm. long. The smaller specimens are like the large one in all essentials, but the granulation of the disk is much more sparse and only surrounds each of the disk-scales and radial shields, leaving all except the very smallest scales quite bare. All of the specimens are white.

Remarks.—It is hard to believe that a West African species from very deep water should occur in water of less than half the depth in the Maldive Islands, but I cannot find any character whatever by which this brittle-star may be distinguished from Koehler's species. It is worthy of note that in the shape of the radial shields the upper and under arm-plates, tentacle-pores and scales, the oral shields, adoral plates and oral papillæ, there is an extraordinary resemblance between this species and *Ophiozonella brachyactis*. It is hard to believe that they belong in different families.

Ophiopallas palmarum Hertz.

Ophiopallas palmarum Hertz, 1927, p. 110 ; pl. 9, figs. 6–9.

Locality.—Station 143 ; Maldive area ; 797 metres. Three specimens.

Range.—Off East Africa, 693–1019 metres.

Notes.—These specimens have the disk 4–5 mm. across. The arms are all broken, but were certainly 6–7 times the disk diameter. The colour is remarkably white, almost chalky.

Remarks.—It is of obvious interest that this recently described novelty from the " Valdivia " collections should be found by the " Mabahiss " in the Maldives. These

specimens correspond well with the description and excellent photographs given by Hertz, but the peculiarities of the distal arm-spines which are stressed by that author are not very conspicuous.

Ophiotrochus longispinus H. L. Clark.

Ophiotrochus longispinus H. L. Clark, 1911, p. 94, fig. 33.

Locality.—Station 185 ; Gulf of Aden ; 2000 metres. Five specimens.

Range.—Japan, Sagami Sea, 1652 metres.

Notes.—The only complete specimen is rather more than 6 mm. across the very flat disk. The slender arms are all more or less broken, the longest stump being only 10 mm. long. The very long spines on the second (apparently first) arm-segment are now missing, but their former presence is indicated by the larger bosses. All in all the specimen is much like the original specimen. The other four individuals are smaller and all the arms are broken off close to the disk.

Remarks.—Ophiotrochus is evidently a rare genus of ophiurans, for since the " Challenger " met with it first near New Guinea, it has seldom been taken. The " Siboga " took two specimens in the East Indies and the " Investigator " took two near the Laccadive Islands. These specimens were regarded by Koehler as identical with the " Challenger " species. The "Albatross " took one specimen in the Sagami Sea which was sufficiently different from Lyman's species to warrant its description as a second member of the genus. The " Valdivia " met with none, the "Albatross " in her very extensive Philippine voyage did not find it, and Dr. Mortensen in his visits to the East Indian region has not taken even one specimen. It is therefore of no little interest that the " Mabahiss " has secured specimens in the Gulf of Aden and that these prove to be the Japanese species. For obvious reasons it is a pity more and better material was not secured.

Ophiernus adspersum Lyman.

Ophiernus adspersum Lyman, 1883, p. 236 ; pl. 3, figs. 19–21.

Localities :

Station 35 ; Gulf of Aden ; 457–549 metres. Eleven specimens.

Station 37 ; Gulf of Aden ; 18–22 metres. Three specimens.

Station 158 ; Maldive area ; 786–1170 metres. One specimen.

Station 193 ; Gulf of Aden ; 1061–1080 metres. Three specimens.

Range.—Tropicopolitan in 291–3653 metres.

Notes.—These specimens call for little comment as they are adults 10–15 mm. across the disk, with arms about eight times as much. It is obvious that the specimens said to be from " Station 37 " did not come from there. They are in very poor condition, having the appearance of coming from a great depth, and probably are from deep water in the Gulf of Aden.

Remarks.—This is one of the most typical of deep-sea ophiurans. The extension of its range by the " Mabahiss " to the Maldives and the Gulf of Aden is quite interesting, as it has not hitherto been known from the area between India and Africa. So the statement that it is tropicopolitan is further justified.

Ophiernus vallincola Lyman.

Ophiernus vallincola Lyman, 1878, p. 122 ; pl. 6, figs. 170–172.
Ophiernus seminudus Lütken and Mortensen, 1899, p. 105.

Localities :

Station 26 ; Gulf of Aden ; 2312 metres. Three specimens.
Station 62 ; northern area of Arabian Sea ; 1893 metres. One specimen.
Station 85 ; northern area of Arabian Sea ; 2000 metres. Four specimens.
Station ? One specimen.

Range.—Antarctic Ocean near Crozet Island ; off southern and eastern Africa ; off tropical America in the eastern Pacific ; 825–2475 metres.

Notes.—These are very typical specimens, ranging from 8 to 21 mm. in disk diameter. A field note with the specimen from Station 62 says : " Colour (Ridgway). Arms ; dragon's blood red, the distal end of each articulation lighter. Disk, oral surface, madder blue, rimmed with dragon's blood red ; aboral surface, madder blue with heart-shaped patches of dragon's blood red at tip of each lobe. Matched in sunlight." This is the first information we have had as to the colour of *Ophiernus* in life. It rouses our curiosity as to whether *adspersum* shows a similar coloration or is essentially different.

Remarks.—The short, more or less circular radial shields on a disk which is otherwise almost or quite bare of scales or other calcareous matter distinguish this species readily from the far more widespread *adspersum*. Hertz (1927, p. 114) expresses the opinion that Lütken and Mortensen's species of Ophiernus from very deep water in the eastern tropical Pacific to which they gave the name *seminudus* is identical with the South African and Antarctic species which Lyman long before called *vallincola*. After a very critical examination of type material of each and of the present " Mabahiss " series, I am reluctantly compelled to agree with her, for I cannot find a single character in which the two forms differ consistently. As the Danish authors were themselves dubious of the validity of *seminudus*, it is quite proper to relegate it to synonymy.

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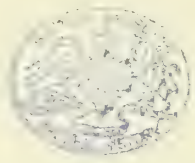

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VOLUME VI, No. 3

STOMATOPODA

BY

B. CHOPRA, D.Sc., F.N.I.

(Zoological Survey of India, Calcutta)

WITH THIRTEEN TEXT-FIGURES

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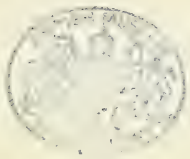

STOMATOPODA*

BY

B. CHOPRA, D.Sc., F.N.I.

(*Zoological Survey of India, Calcutta*)

WITH THIRTEEN TEXT-FIGURES.

I am grateful to Lt.-Col. R. B. Seymour Sewell, F.R.S., for the privilege of examining and reporting on the interesting collection of adult Stomatopods made, under his leadership, by the John Murray Expedition. The collection is small, comprising only sixteen species and varieties, but some of these have proved to be of great interest.

The genus *Squilla* is represented in the collection by nine species, one of which, from the African coast, is described as new. This species, *S. zanzibarica*, resembles the Mediterranean *S. mantis* in several important characters, but probably its nearest ally is the form, collected once only, and more than forty years ago, from Borneo. Another species of outstanding interest in the collection is *S. investigatoris* Lloyd. This species was originally collected in large numbers in 1906 by the R.I.M.S. " Investigator ", at one station in about 110 fathoms of water, on the South Arabian coast, close to the Gulf of Aden. The great interest of this species lies in the fact that the dactylus of the raptorial claw bears a very much larger number of teeth than in any other species of the genus, and, further, this number varies enormously in the species. The number of raptorial teeth is generally a very constant character in the Stomatopoda. In *S. investigatoris*, which seems to be a stable species in all other characters, there is, however, a wide range of variation in this respect. The John Murray Expedition collected a fair number of examples of this species, and these show a range of variation almost equal to that described by Lloyd. The original finding and the present records of the species suggest that *S. investigatoris* probably has a very limited range of distribution. A large number of fragments of this species were also collected at the depth of 1300 metres ; this is believed to constitute a depth record for any Stomatopod.

Only one specimen of the genus *Pseudosquilla* was collected by the Expedition. This is in the *monodactyla* stage, but as some of the adult characters, leading to a definite identification of the species, are present, this has been dealt with in the present report.

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The new species of *Lysiosquilla* described in this report shows some very peculiar features. It does not seem to have any near allies in the Indo-Pacific region, but shows a rather close resemblance to two species from the West Indies.

Gonodactylus is somewhat poorly represented in the collection, there being only two, or possibly three, forms, all belonging to the *chiragra* group of the genus. In connection with the identification of this material I have re-examined the extensive collections in the Indian Museum, and have briefly discussed the position and relationships of the different members of this group. One of the forms has been provisionally identified as *G. demani* var. *espinosus* Borradaile ; this had so far been recorded only once from the Fiji group of islands in the Southern Pacific. The specimens of this variety in the John Murray collection show some interesting variations. One small specimen, probably referable to *G. chiragra*, was found with the material collected at a depth of 1300 metres.

The sixteen species and varieties in the collection are listed below, together with the stations at which these were taken. For the sake of convenience, some details of the stations at which Stomatopods were collected, taken from the " List of Stations " in Sewell's introductory part in the present series of Reports, and the names of the species collected at each station are appended.

Kemp's masterly monograph (1913) on the Indo-Pacific Stomatopoda has been a source of invaluable help and inspiration to me throughout. His clear grasp and lucid treatment of the subject makes the task of dealing with any collection of Indo-Pacific Stomatopods comparatively easy. Bigelow's work (1931) on the Stomatopoda of the Southern and Eastern Pacific Oceans has also been of great help.

I have not considered it necessary to give detailed synonymies of the species. These have been given by Kemp and brought up to about 1930 by Bigelow for the species that he dealt with. Dollfus (1938) has given complete synonymies for the species included in his paper on the Red Sea Stomatopods.

The three authors mentioned in the previous paragraph and Komai (1927) have published very useful bibliographies. Balss* has recently published a very comprehensive and up-to-date list of references, which is as nearly complete as any list of this nature can be. In the list of literature at the end of the present report I have only included some of the important papers referred to in my account of the species.

The drawings illustrating this paper have been prepared under my supervision, by Babu Ram Bagchi with his usual care and accuracy, and for this my best thanks are due to him.

Dr. Waldo L. Schmitt, of the United States National Museum, has kindly examined, at my request, the type-specimen of *Squilla mantoidea* Bigelow, and has informed me that the mandibular palp is present in this species. I am grateful to Dr. Schmitt for help in this matter.

Finally, I would like to express my indebtedness to Dr. Baini Prashad, Director of the Zoological Survey of India, for the generous help and facilities he has always and ungrudgingly given me. The very rich collection of Stomatopods, containing a large number of types, in the Zoological Survey, under his charge, has been available to me for examination and comparison throughout the course of this work.

* Balss, H., Stomatopoda : in Dr. H. G. Bronn's 'Klassen und Ordnungen des Tierreichs', V, Abt. 1, Buch 6, Tiel II, pp. 149–173 (1938).

LIST OF SPECIES IN THE COLLECTION.

Genus **SQUILLA** Fabricius.

	Station from which collected.
Squilla fasciata de Haan	146
S. gilesi Kemp	70, 75
S. zanzibarica sp. nov.	106
S. gonypetes Kemp	72
S. indica Hansen	137, 147
S. investigatoris Lloyd	79, 190, 194
S. ? investigatoris Lloyd	33
S. raphidea Fabricius	72
S. annandalei Kemp	75

Genus **PSEUDOSQUILLA** Dana.

Pseudosquilla ciliata (Fabricius)	M.B. II(*a*)

Genus **LYSIOSQUILLA** Dana.

Lysiosquilla maculata (Fabricius)	Extra, Aden Harbour.
L. multifasciata Wood-Mason	72
L. sewelli sp. nov.	176, 194

Genus **GONODACTYLUS** Latreille.

Gonodactylus demani var. *spinosus* Bigelow	37, M.B. I(*b*), M.B. I(*d*)
G. demani var. *? espinosus* Borradaile	45, M.B. I(*b*)
G. chiragra (Fabricius) *s.l.*	33

List of Stations at which Stomatopods were Collected, with the Names of Species Obtained at each Station.

Red Sea.

Station M.B. I(*b*). 13° 39′ 30″ N., 42° 43′ 00″ E., bay between Gt. Hanish and Suyul Hanish Islands; 17.ix.33; 29 metres; bottom—sand, shells and coral; rectangular dredge, width 18 in.

Gonodactylus demani var. *spinosus* Bigelow.

G. demani var. *? espinosus* Borradaile.

Station M.B. I(*d*). 13° 39′ 30″ N., 42° 43′ 00″ E., bay between Gt. Hanish and Suyul Hanish Islands; 17.ix.33; 26 metres; bottom—sand, shells, and coral; rectangular dredge, width 18 in.

Gonodactylus demani var. *spinosus* Bigelow.

Aden Harbour.

Station Extra. Aden Harbour; 17.x.33; surface; hand net.

Lysiosquilla maculata (Fabricius).

Gulf of Aden.

Station 33. 13° 41′ 00″ N., 48° 17′ 00″ E. to 13° 40′ 00″ N., 48° 19′ 00″ E.; 15.x.33; 1295 metres; bottom—green mud; Agassiz trawl.

Fragments of *Squilla investigatoris* Lloyd.

Gonodactylus chiragra (Fabricius).

Station 37. 12° 47′ 30″ N., 45° 04′ 30″ E. to 12° 50′ 00″ N., 45° 05′ 00″ E.; 17.x.33; 18 metres; bottom—sand; otter trawl.

Gonodactylus demani var. *spinosus* Bigelow.

Station 176. 12° 04′ 06″ N., 50° 38′ 36″ E.; 2.v.34; 695 metres; bottom—green mud and sand; Agassiz trawl.

Lysiosquilla sewelli sp. nov.

Station 190. 13° 49′ 00″ N., 47° 49′ 12″ E.; 6.v.34; 183 metres; bottom—green sand and mud; grab of modified "Petersen" type.

Squilla investigatoris Lloyd.

Station 194. 13° 16′ 00″ N., 46° 20′ 24″ E. to 13° 16′ 36″ N., 46° 14′ 00″ E.; 7.v.34; 220 metres; bottom—?; Agassiz trawl.

Squilla investigatoris Lloyd.

Lysiosquilla sewelli sp. nov.

South Arabian Coast.

Station 45. 18° 03′ 30″ N., 57° 02′ 30″ E.; 29.x.33; 38 metres; bottom—lithothamnion; triangular dredge, each side 4 ft.

Gonodactylus demani var. ? *espinosus* Borradaile.

Station 79. 22° 12′ 48″ N., 59° 49′ 42″ E.; 30.xi.33; 102 metres; bottom—green mud; "Salpa" dredge, width 4 ft.

Squilla investigatoris Lloyd.

Station M.B. II(*a*). 17° 33′ 30″ N., 56° 01′ 30″ E., costal zone of N. of Jezirat Hallaniya, Khorya Morya Islands, Arabian Coast; 28.x.33; 11 metres; bottom—coarse sand; rectangular dredge, width 18 in.

Pseudosquilla ciliata (Fabricius).

Gulf of Oman.

Station 70. 25° 34′ 12″ N., 57° 23′ 30″ E. to 25° 33′ 00″ N., 57° 25′ 12″ E.; 25.xi.33; 196 metres; bottom—soft, green mud; otter trawl.

Squilla gilesi Kemp.

Station 72. 25° 38′ 18″ N., 56° 26′ 36″ E.; 26.xi.33; 73 metres; bottom—coarse sand and shells; Agassiz trawl.

Squilla gonypetes Kemp.

S. raphidea Fabricius.

Lysiosquilla multifasciata Wood-Mason.

Station 75. 25° 10′ 48″ N., 56° 47′ 30″ E. to 25° 09′ 48″ N., 56° 47′ 30″ E.; 28.xi.33; 201 metres; bottom—green mud; grab of modified "Petersen" type.

Squilla gilesi Kemp.

S. annandalei Kemp.

Zanzibar Area.

Station 106. 5° 38′ 54″ S., 39° 15′ 42″ E. to 5° 40′ 18″ S., 39° 17′ 36″ E.; 12.i.34; 212 metres; bottom—green mud; Agassiz trawl.
Squilla zanzibarbica sp. nov.

Maldive Area.

Station 137. 0° 36′ 00″ S., 73° 12′ 48″ E., anchorage Addu Atoll; 23.iii.34; 46 metres; bottom—white mud; grab of modified "Petersen" type.
Squilla indica Hansen.

Station 146. 4° 50′ 18″ S., 72° 52′ 48″ E. to 4° 53′ 00″ S., 72° 55′ 24″ E.; 2.iv.34; 37 metres; bottom—soft, cream-coloured mud; otter trawl.
Squilla fasciata de Haan.

Station 147. 4° 53′ 12″ S., 72° 54′ 30″ E., anchorage Horsburgh Atoll; 2.iv.34; 27 metres; bottom—soft, cream-coloured mud; grab of modified "Petersen" type.
Squilla indica Hansen.

SYSTEMATIC ACCOUNT.

Genus **SQUILLA** Fabricius.

Squilla fasciata de Haan.

Squilla fasciata Kemp, 1913, pp. 34–36, pl. i, figs. 21–23; Hale, 1924, p. 496; Komai, 1927, pp. 309, 310; Tweedie, 1934, pp. 35, 36.

Occurrence.—Station 146, Maldive Sea, 37 metres. 1 ♂, 74 mm.*

Descriptive Notes.—The single large male in the collection agrees closely with Kemp's detailed description, as also with named specimens from various localities in the collection of the Indian Museum. The distinctive colour pattern, mentioned by Kemp, is, however, lacking; only the terminal portions of the uropods are brown.

Most of the secondary sexual characters, mentioned by Komai, are seen in the present specimen, as also in the other large-sized examples that I have examined. The shape of the propodus of the raptorial claw is markedly different in the two sexes.

The post-anal carina on the ventral surface of the telson is fairly well developed in the Maldive example, but the two somewhat interrupted carinæ, sometimes present on either side of it, are lacking. The basal segment of the exopod of the uropod is, as is the case in all the specimens that I have seen, strongly ridged and grooved in a longitudinal direction on both the dorsal and the ventral surfaces.

Bouvier (1915, p. 308) has described a closely-related species from Mauritius under the name *S. fallax*, but, as was pointed out by Kemp and Chopra (1921, p. 300), this species differs from *S. fasciata* in a number of important characters, including the total suppression of the mandibular palp.

The two species, *S. ambigua* and *S. incerta*, described by Hansen (1926, pp. 6–10)

* Throughout the report the total length of the specimen, unless otherwise stated, represents the distance, in a median line, between the anterior end of the rostrum and the posterior extremity of the telson.

from the " Siboga " collection are also said to be somewhat close allies of *S. fasciata*, but, judging from Hansen's descriptions of the two species, the differences between these and de Haan's species (including the suppression of the mandibular palp in both of Hansen's species) are far too numerous, especially in the case of *S. incerta*, to require any critical comparison.

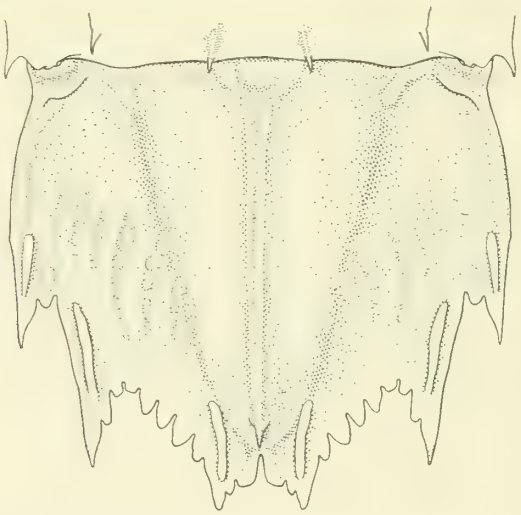
Distribution.—*S. fasciata* is mostly known from Japan, but has also been recorded outside this area from a few places. Komai has given a list of the Japanese localities from which the species has been recorded. It is also known from the Chinese Sea, South Australia, Singapore, Mergui, Tavoy and the Andaman Islands in the Bay of Bengal. The present record of the species from the Maldives extends its range considerably westwards.

S. fasciata is not so far known to live in deep waters ; there is no record of it from a depth greater than 50 fathoms.

Squilla gilesi Kemp.

Squilla gilesi Kemp, 1913, pp. 39, 40, pl. ii, figs. 25–27 ; Chopra, 1934, pp. 22, 23 ; Boone, 1938, pp. 203–208, pl. lxxi.

Occurrence.—Station 70, Gulf of Oman, 196 metres. 1 ♂, 1 ♀, 60 and 39 mm. Station 75, Gulf of Oman, 201 metres. 2 ♀♀, 78 and 66 mm.



Text-fig. 1.—*Squilla gilesi* Kemp. Telson of a large female, dorsal view. × 4½.

Descriptive Notes.—I have compared the John Murray Expedition specimens with the types in the collection of the Indian Museum and have found them to agree with the latter in every important character.

The secondary sexual characters of the male are generally well marked, but the swelling of the distal margin of the telson is sometimes not very distinct in medium-sized males. In the Indian Museum there are, among others, four male specimens collected by the R.I.M.S. " Investigator " from the north-east part of the Bay of Bengal. In one of these, 59 mm. long, the margins are very much swollen, as shown in Kemp's fig. 27 on pl. ii, while in another example, 53 mm. long, the swelling, though much less, can still be distinctly made out. In another male of the same size as the last mentioned example there is hardly any swelling at all. Similarly in the John Murray Expedition male, 60

mm. long, there is practcially no swelling along the margins. The median carina of the telson is swollen in all the males, much more so in large-sized examples than in small and medium-sized ones. I give here a figure of the dorsal surface of the telson of the large female (78 mm. long) from the present collection, and a comparison of it with Kemp's figure of the male telson clearly brings out the secondary characters of the telson in the two sexes. The raptorial claw is also appreciably different in the two sexes, the differences being discernible even in medium-sized specimens. These differences have been enumerated by Kemp and can be seen in the figure published by me in 1934.

The anterior border of the carapace on either side of the rostrum is distinctly slanting, considerably more so in young examples than in adults. The lobe on the inside of the longer limb of the bifurcate process of the uropod is greatly reduced in all the large specimens I have seen, but in smaller examples it is sometimes well developed and sometimes reduced.

Distribution.—*S. gilesi* is known both from the Bay of Bengal and the Arabian Sea. Boone has recently recorded it from Singapore also. In the Arabian Sea it has already been recorded from the Persian Gulf; the John Murray Expedition specimens are from the adjacent Gulf of Oman.

The species has not so far been collected in depths greater than 110 fathoms. Along the eastern coast of India it is littoral also, occurring quite close to the coast in depths of 20 fathoms and less.

Squilla zanzibarica, sp. nov.

Occurrence.—Station 106, Zanzibar area, 212 metres. 1 ♂, 59 mm. Type.

Descriptive Notes.—A species of *Squilla*, that appears to be a near ally of the Mediterranean *S. mantis* Latreille, is represented in the John Murray Expedition collection by a single female specimen from the African coast. Another close ally of the new species, and of *S. mantis*, is the form described by Bigelow in 1893 (see Bigelow, 1894, pp. 521–523) from Borneo under the name *S. mantoidea*. *S. zanzibarica* appears to show a greater resemblance to *S. mantoidea*, than to the Mediterranean species. The most important difference between the three species is in the shape of the lateral processes of the sixth and seventh thoracic somites—structures that are generally very constant in species of *Squilla*.

The carapace (Text-fig. 2) is considerably narrowed anteriorly, the breadth behind the antero-lateral spines being almost three-fifths of its greatest breadth, a little in front of the rounded postero-lateral angles. The surface is for the most part smooth, but the carinæ are very distinct. The median carina is well marked throughout, even anterior to the point of bifurcation, which starts about a third of the carapace length from the anterior end. A narrow triangular space, with somewhat sinuous sides, is enclosed by the bifurcation. The dorsal pit is clearly seen a little behind the point of bifurcation. The intermediate carina is interrupted for some distance in the posterior half of the carapace. The lateral carina is prominent throughout and ends at the anterior end in the sharp antero-lateral spine of the carapace. The lateral margins are somewhat thickened. The cervical and the gastric grooves are deeply impressed.

Unlike *S. mantoidea*, the rostrum is broader than long, has anteriorly convergent sides and is broadly rounded at the tip. The median carina is sharp and the margins are somewhat thickened.

The eyes are large and triangular, and the corneal axis is almost at right angles to

the peduncular axis, more or less as in Bigelow's species (see Bigelow, 1894, p. 522, text-fig. 14). The cornea is broader than any part of the stalk, and the corneal axis is only very slightly longer than the peduncular. The antennules and antennæ are as in *S. mantoidea*, but the antennary scale is proportionately longer. The ophthalmic somite is exposed in dorsal view, and its anterior margin is rounded. The lateral processes of the antennulary somite are somewhat large, horn-like structures, and each has a short, oblique, raised carina on the dorsal surface near the base. The processes of the ophthalmic somite are small and flat, and are rounded distally, as in *S. mantis*.

Text-fig. 2.—*Squilla zanzibarica* sp. nov. Carapace and first three exposed thoracic somites. × 3.

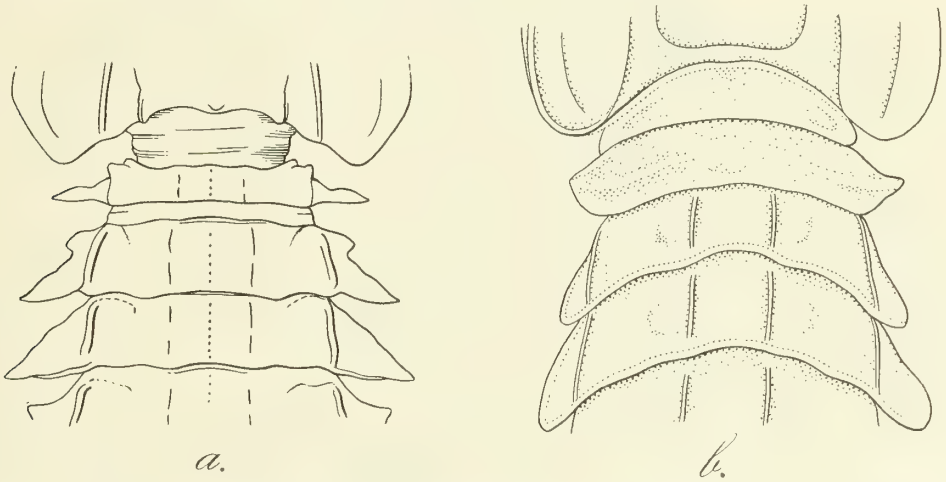
The mandibular palp is present and has the usual structure. There are epipodites on the first four legs. The inner ramus of the walking legs is linear.

The raptorial claw is as described by Bigelow for *S. mantoidea*. The dorsal carina of the carpus ends before reaching the distal end in a blunt lobe. In *S. mantis* this carina ends in two spines, and in Bigelow's species there is said to be one spine. The dactylus is evenly curved on the outside, and has a small, but fairly prominent, lobe near the base. It bears six teeth.

The lateral process of the fifth thoracic somite is, as in *S. mantoidea*, short, straight, obliquely flattened and acute at the tip. The ventral spine on this segment is triangular and sharp, and is directed somewhat forward. The lateral processes of the next two somites differ markedly from those of *S. mantoidea* (Text-fig. 3, *a*) or *S. mantis* (Text-fig. 3, *b*).

The sixth segment is bilobed on the margin, the posterior lobe being only a little longer than the anterior. Both the lobes are large ; the anterior is beak-like, while the posterior is triangular. There is a deep cleft between the two lobes, and both end in acute points. The margin of the seventh somite is very much like that of the sixth, but the anterior beak-like lobe is considerably smaller than the posterior. The eighth somite has a short, acutely-pointed anterior lobe, and a still smaller, blunt posterior lobe. For purposes of comparison I give here figures of the fifth, sixth and seventh thoracic somites of *S. mantis* and *S. mantoidea* after Giesbrecht (1910, pl. i, fig. 1) and Bigelow (1894, p. 521, text-fig. 13) respectively. The submedian carinæ are well marked on the thoracic somites.

The eight longitudinal carinæ are distinct on all the abdominal somites. The intermediate carinæ of somites 2–6 are broken up into two each, a short anterior and a very much longer posterior portion. The submedian and the intermediate carinæ of the sixth somite are swollen, and there is a blunt ridge running from near the base of the inter-



Text-fig. 3.—First three exposed thoracic somites of (*a*) *Squilla mantoidea* Bigelow (after Bigelow) ; (*b*) *Squilla mantis* Latreille (after Giesbrecht).

mediate carina outwardly in an oblique direction to the anterior margin of the segment, close to the base of the lateral carina. The following carinæ end in spines :

Carinæ.	Abdominal somites.
Submedian	5, 6
Intermediate	3, 4, 5, 6
Lateral	1, 2, 3, 4, 5, 6
Marginal	1, 2, 3, 4, 5

In *S. mantoidea* the submedian carinæ of the fifth somite do not end in spines.

The telson (Text-fig. 4, *a*) is a little broader than long, and agrees closely with Bigelow's description of *S. mantoidea*. The median keel is very prominent and ends in a large overhanging spine before quite reaching the posterior border. The rows of shallow pits and the keels on the inside of the rather long and slender marginal teeth are as described by Bigelow. The mid-ventral keel is rather short and fades away altogether even before reaching the middle of the telson. The number of marginal denticles is more than described for *S. mantoidea*. The submedian denticles are closely crowded together ; there are at least five or six main ones, but on account of minute secondary teeth on some of them

their exact number is difficult to make out. The somewhat complicated arrangement of these denticles is shown in Text-fig. 4, *b*. There are 14 or 15 intermediate denticles on either side ; in *S. mantoidea* their number is said to be 11 or 12. The posterior margin of the telson on the inside of the denticles is not thickened, as is the case in *S. mantis*. The median notch is rather deep. The præ-lateral lobe is not very distinct.

Text-fig. 4.—*Squilla zanzibarica* sp. nov. (*a*) Last two abdominal somites, telson and uropods of one side. × 4½. (*b*) Part of posterior margin of telson to show the arrangement of submedian denticles. × 21.

Just in front of the base of the uropod the sixth abdominal segment bears a short spine at the anterior end of the margin in a slightly ventral position. The peduncular segment of the uropod has a dorsal spine overhanging the proximal segment of the exopod and two rather prominent longitudinal carinæ on its dorsal surface. The inner limb of the bifurcate process is very much longer than the outer and the lobe on its outer margin is much better developed than shown in Giesbrecht's figure of *S. mantis*. There are 13 movable spines on the outer margin of the proximal segment of the exopod on one side and 12 on the other ; the most proximal spine is very minute and is possibly broken off

on one side. In *S. mantoidea* and *S. mantis* there are only eight such spines. The distal segment of the exopod, measured on its ventral aspect, is much shorter than the proximal, even more so than in *S. mantoidea*; in *S. mantis* these segments are subequal. The inner margin of the bifurcate process is serrate.

The measurements, in millimetres, of the single specimen that I have examined are given below:

Median length of body from tip of rostrum to posterior border of telson	59·0
,, ,, of carapace, excluding rostrum	13·5
Anterior breadth of carapace behind antero-lateral spines	6·2
Greatest breadth of carapace in front of postero-lateral angles	10·6
Median length of rostrum	1·9
Basal breadth of rostrum	2·3
Length of corneal axis of eye	3·1
,, of peduncular axis of eye	3·0
,, of antennary scale	10·0
Greatest breadth of abdomen	13·5
Median length of telson	9·6
Greatest breadth of telson	11·5
Median length (ventral) of proximal segment of exopod of uropod	7·5
,, ,, ,, of distal segment of exopod of uropod	5·0

The specimen has very little coloration left. There is, however, a faded patch of light brownish colour on the middle of the second abdominal somite, and two small, but more distinct, patches, one on either side of the submedian carina of the fifth abdominal segment, close to its posterior border. There may possibly have been a transverse band on the carapace in the region of the cervical groove and the telson also may have been lightly pigmented close to the margins. The inner uropod and the distal part of the bifurcate process also show traces of pigmentation.

The single female specimen on which *S. zanzibarica* is based was collected by the John Murray Expedition on January 12th, 1934, with Agassiz trawl at Station 106 (5° 38′ 54″ S., 39° 15′ 42″ E. to 5° 40′ 18″ S., 39° 17′ 36″ E.), a little to the north-west of Zanzibar at a depth of 212 metres. The sea bottom at this place consisted of green mud.

S. mantoidea Bigelow is also known from a single female example, 120 mm. long, from Borneo. The exact locality and the depth from which it was obtained are not recorded. *S. mantis*, on the other hand, is very commonly met with in the Mediterranean, and it has also been recorded along the coast of Portugal, in the English Channel and in the North Sea; Giesbrecht (1910, p. 33) regards its presence in the Atlantic Ocean as open to doubt, but it is occasionally taken on the S.W. coasts of England.

Some of the important differences between Bigelow's *S. mantoidea* and the new species may be briefly enumerated here.

(1) The rostrum is broader than long and its sides distinctly converge anteriorly.

(2) The carapace is somewhat longer as compared with its posterior breadth.

(3) The lateral processes of the sixth and seventh thoracic somites are prominently bilobed, the anterior lobe being beak-like and shorter than the posterior.

(4) The submedian carinæ of the fifth abdominal somite end in spines.

(5) The ventral keel on the telson is short.

(6) The number of intermediate denticles on the telson is larger.

(7) The terminal segment of the outer uropod is proportionately shorter.

(8) There are more movable spines on the outer margin of the proximal segment of the outer uropod.

S. mantoidea and *S. zanzibarica* differ from *S. mantis*, among other characters, in having transverse eyes, in the margin of the sixth thoracic somite being bilobed, in having the posterior margin of the telson not thickened and in the terminal segment of the outer uropod being distinctly shorter than the proximal.

The mandibular palp is present in all the three species. Dr. Waldo L. Schmitt, of the United States National Museum, has, at my request, very kindly examined the type-specimen of *S. mantoidea* Bigelow and has found the mandibular palp to be present and well developed.

Squilla gonypetes Kemp.

Squilla gonypetes Kemp, 1913, pp. 54, 55, pl. iv, figs. 42–44 ; Kemp and Chopra, 1921, pp. 300, 301 ; Gravier, 1938, pp. 166–168 ; Dollfus, 1938, p. 193.

Occurrence.—Station 72, Gulf of Oman, 73 metres. 2 ♂♂, 4 ♀♀, 35–56 mm.

Descriptive Notes.—Of the six specimens in the present collection, five are unfortunately without their raptorial claws, while the sixth, a female, has only one claw present. This last-mentioned specimen is 56 mm. long from the tip of the rostrum to the posterior border of the telson, and is thus only a little longer than the largest example recorded by Kemp, which, measured in a similar way, is only 53 mm. long.

The specimens agree on the whole very closely with the type-specimens and the other named material in the Indian Museum collection. The species resembles *S. quinquedentata* Brooks (*vide* Kemp, 1913, pp. 52, 53) rather closely, but can be distinguished from it by the characters enumerated by Kemp, and especially by the shape of the lateral processes of the sixth and seventh thoracic somites.

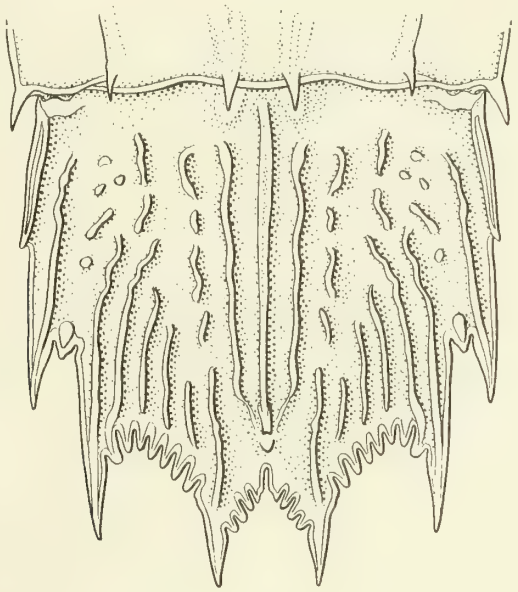
The largest female in the John Murray collection shows an interesting feature. On the dorsal surface of the telson (Text-fig. 5) there is the usual median carina and the oblique rows of pits. These pits have become confluent, forming rather deep grooves, as is sometimes the case in this species, and more often in *S. quinquedentata*, but the margins of these grooves have become distinctly thickened, forming a series of oblique, rounded carinæ, as shown in the accompanying text-fig. In addition to these oblique carinæ there are two (one complete and one considerably broken up) longitudinal carinæ on either side of the median carina. The general appearance of the telson in this specimen is somewhat like that of *S. fasciata* de Haan (see Kemp, 1913, p. 35, pl. i, fig. 23). Traces of these carinæ, especially the oblique ones, are, however, faintly visible in the larger of the two type-specimens of the present species also, but the longitudinal carinæ on either side of the median carina cannot be made out. In another male specimen in the present collection the rounded oblique carinæ are fairly distinct, but the longitudinal carinæ are hardly noticeable.

The spine formula is as given by Kemp, but there are sometimes slight variations. Thus, in one or two specimens the intermediate carina of the third abdominal somite does not terminate in a distinct spine, but in a somewhat acute point. Similarly, in two examples, a male and a female, the lateral carina of the first abdominal somite terminates

in a distinct spine, while in the remaining four specimens this carina ends in a spine only on the last five abdominal somites, as is generally the case in this species.

The colour of the species is as described by Kemp, and the two patches on the abdomen are clearly seen in all the specimens. In addition all my specimens have small pigment marks or patches on the inside of the lateral carina on the first five abdominal somites and similar marks on the outside of these carinæ on the sixth and seventh thoracic segments. These marks, though not mentioned by Kemp, are faintly visible in the types and several other specimens in the Museum collection also.

The female specimen from the Gulf of Suez, described by Gravier (1938) and also referred to by Dollfus (1938), does not quite agree with typical examples of *S. gonypetes* in the shape of the lateral processes of the sixth and seventh thoracic somites, and in a few other minor characters.



Text-fig. 5.—*Squilla gonypetes* Kemp. Dorsal surface of telson of a female 56 mm. long. × 6.

S. gonypetes resembles *S. quinquedentata* so closely that Sunier (1918, p. 66) has suggested that it is only a young form of the latter. Kemp and I (1921) were unable to agree with this view, chiefly on the ground that the eyes are more oblique in *S. gonypetes* than in Brooks' species, whereas if the former were only a young of the latter one should expect to find the cornea more transversely placed in it. The lateral processes of the sixth and seventh thoracic somites are also different in the two species ; the shape of these processes always remains more or less constant in a species irrespective of age. The dark patches on the second and fifth abdominal somites are very characteristic of the present species.

Distribution.—*S. gonypetes* has been recorded from the China Sea, the Java Sea, the Mergui Archipelago, the Andaman Islands, the Arakan and Vizagapatam coasts of Burma and India respectively, the Persian Gulf and the Gulf of Suez. The greatest depth at which the species has so far been taken does not exceed 60 fathoms. The present record from the Gulf of Oman at the mouth of the Persian Gulf at a depth of about 40 fathoms does not extend either the geographical or bathymetrical range of the species.

A small specimen about 20 mm. long, taken from Station 72 along with the six specimens described above, is also referred to *S. gonypetes*. The specimen is badly crushed and extensively damaged; the raptorial limbs are also missing. The few characters that can be made out suggest its being conspecific with the examples referred to above.

Squilla indica Hansen.

Squilla indica Hansen, 1926, pp. 12–14, pl. i, figs. 4*a*–4*c*; Chopra, 1934, pp. 35–38.

Occurrence.—Station 137, Maldive area, 46 metres. 1 ♀, 24·5 mm.

Station 147, Maldive area, 27 metres. 1 ♂, 28·5 mm.

Descriptive Notes.—The two specimens in the present collection that I have referred to Hansen's species, though considerably smaller than the one I described in 1934, agree with it, as also with Hansen's description of the species, in all material respects. There are 7 teeth, including the terminal one, on the raptorial dactylus in each of the 4 claws present; in one of the "Siboga" specimens there were 8 such teeth. The lateral processes of the fifth thoracic somite are very typical of the species, and these, as also the processes of the sixth and seventh somites, agree exactly with the description and figure given in 1934. The species is further characterized by having very few spines terminating the longitudinal carinæ of the abdominal somites. Hansen has made no mention of these spines, but in the example from the Nicobar Islands previously described by me the submedian, intermediate and lateral carinæ of the last two abdominal somites only were found to end in spines, while the marginal carina terminated in a spine on the fourth and fifth segments only. In the present specimens the condition is somewhat similar and the spine formula is as given below:

Carinæ.	Abdominal somites.	
	Male.	Female.
Submedian	5, 6	5, 6
Intermediate	4*, 5, 6	5, 6
Lateral	4†, 5, 6	5, 6
Marginal	4, 5	4, 5

The median length of the rostrum is only a little more than its basal breadth. The antennular peduncle is slightly longer than the median length of the carapace. The anterior margin of the ophthalmic somite is evenly rounded, with a slight emargination in the middle. The lateral processes of the antennulary somite are small, flattened, leaf-like structures, somewhat more truncate distally than shown in Hansen's figure. The mandibular palp is absent and epipodites are present on the first two legs only.

The telson is as already described. The marginal teeth are rather long, and the denticles, except for the rounded, lobe-like structures, one each on the inside of the submedian and the intermediate teeth, are all like minute spinules.

The lobe on the outer margin of the inner spine of the bifurcate process of the uropod is, as usual in the species, large and prominent, and the margin anterior to the lobe deeply concave.

* The intermediate carinæ of the fourth somite end in sharp angles, rather than spines.

† The lateral carina of the fourth somite ends in a sharp spine on one side only.

The specimens have no distinctive colour-pattern, though the outer half of the terminal segment of the exopod and the distal portion of the endopod of the uropod are tinged with brownish colour.

The measurements in millimetres of the two specimens in the John Murray collection are given below :

	Male.	Female.
Total length of body	28·5	24·5
Median length of carapace	6·7	6·0
Breadth of carapace behind antero-lateral angles	3·0	2·8
Length of rostrum	1·3	1·1
Basal breadth of rostrum	1·1	1·0
Breadth of cornea	1·8	1·6
,, of telson	5·2	4·6
Median length of telson	4·3	3·6

The corneal index in both the specimens is about 3·7.

The question of the affinities of *S. indica* was discussed in 1934. The species seems to belong to the *nepa* group of *Squilla*, but its position in the group is very uncertain. The total absence of the mandibular palp, the great reduction in the number of epipodites, the larger number of raptorial teeth, the peculiar shape of the lateral processes of the free thoracic somites, and the great reduction of the spines on the abdominal segments are some of the characters that appear to be peculiar to this species.

Distribution.—*S. indica* was so far known only from the Celebes Sea (Hansen) and the Nicobar Islands in the Bay of Bengal (Chopra) ; the present record from the Maldives in the Arabian Sea, therefore, considerably extends its range westwards. The species has not been recorded from any considerable depths ; the two " Siboga " specimens were collected in 22 and 31 metres respectively, while the Nicobar example was taken in 13 fathoms of water. The present specimens also are from comparatively shallow waters, one from 46 and the other from 27 metres. They were collected with a grab and the bottom at the place of capture consisted of white mud and soft cream-coloured mud respectively.

S. indica does not appear to grow to a large size ; the largest specimen so far recorded is only 41 mm. long.

Squilla investigatoris Lloyd.

Squilla investigatoris Lloyd, 1907, pp. 10–12 ; Lloyd, 1908, pp. 29–35, pls. ii, iii ; Kemp, 1913, pp. 80–82, pl. vi, figs. 67, 68.

Occurrence.—Station 190, Gulf of Aden, 183 metres. 7 ♂♂, 7 ♀♀, 73–83 mm.

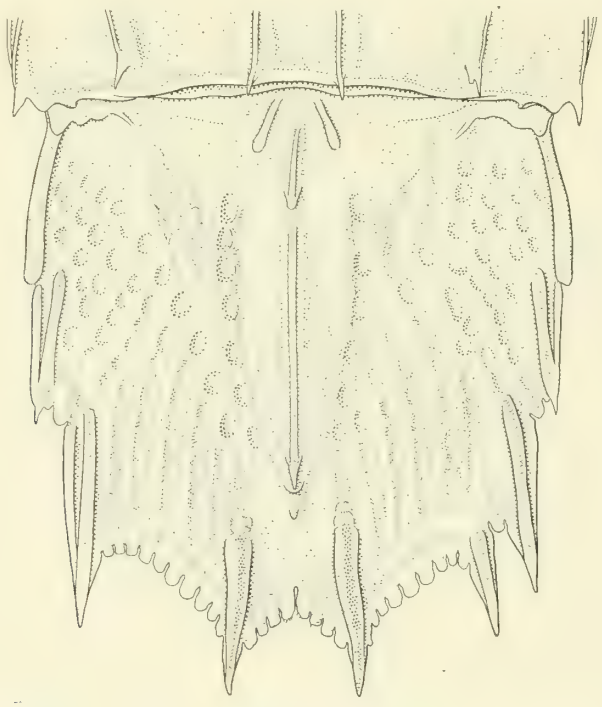
Station 194, Gulf of Aden, 220 metres. 3 ♂♂, 1 ♀, 77–105 mm.

Descriptive Notes.—The 18 specimens in the present collection agree very closely with the detailed descriptions given by Lloyd and Kemp, as also with the type-material preserved in the Indian Museum. The colour of the body, though showing slight variations in individual examples, is generally as described by Kemp.

There are, however, a few minor differences in the present specimens that may be mentioned. In several examples the rostrum is distinctly longer than its basal breadth, the somewhat upturned margins hardly converge at all anteriorly and the apex is more broadly rounded than is shown in Kemp's figure. The outer inferior margin of the merus

of the raptorial claw is more sharply angled than shown by Kemp, though in the type-material the condition is more or less as in the present examples.

The telson (Text-fig. 6) is very much like that of *S. massavensis* Kossmann (see Kemp, 1913, pp. 76–78, and Dollfus, 1938, pp. 188–190, text-figs. 2 and 3). The dorsal surface is profusely pitted, the pits being arranged in slanting rows. One row of pits, more prominent than the others, runs on each side of the median carina ; these two rows converge to a point beneath the apex of the spine that terminates this carina. The pits are closely arranged and sometimes form a sort of a channel, the two walls of which are thickened and in large specimens are broken up into low tubercles. The surface between the other rows of pits is also sometimes unevenly thickened in large examples. The tubercles on the side of the median carina are not, however, as prominent as in examples of *S. massavensis* of the same



TEXT-FIG. 6.—*Squilla investigatoris* Lloyd. Telson of a male specimen, about 82 mm. long, from the type-series, dorsal view. × 5.

size. The type-specimens also show these characters clearly, as can be seen in the accompanying text-figure. In larger individuals the condition is still more like that of *S. massavensis*, the walls of the channel on the side of the median carina being greatly thickened and broken up into distinct tubercles ; this condition is seen in the fragmentary specimen from Station 79 referred to on p. 157.

The ventral surface of the telson is more or less smooth. The anal opening is on a raised papilla and there is a short longitudinal carina running backwards from it for a short distance. In larger examples this carina is broken up into low tubercles. Near the outer anterior angle, on the ventral surface of the telson, there is on each side a short oblique carina running for a little distance obliquely inwards.

The number of movable spines on the outer margin of the basal segment of the exopod of the uropod is generally 8, as described by Lloyd and Kemp, but in two or three specimens 9 such spines have been found.

The short median longitudinal keel on the ventral surface of the eighth thoracic somite is very prominent in both the sexes.

The most important character of the present species is the large number of teeth that the raptorial dactylus carries on its inner margin ; another equally, if not more, remarkable feature is the great variation shown in the number of these teeth. In most species of the genus *Squilla* the number of raptorial teeth does not exceed 6, and the number found in any particular species is as a rule very constant. In *S. investigatoris* the number of these teeth varies between 10 and 18. Lloyd (1908) examined 461 specimens belonging to different species of *Squilla* from the Indian Museum collection, and found that 451 of these strictly conformed to the normal types of dentition of the different species to which they belonged and that variation from the normal type of dentition of the species occurred to the extent of about 2% of individuals only. His 17 specimens of *S. investigatoris*, on the other hand, showed 11 different types of dentition.

I have carefully counted the teeth in the 18 specimens in the present collection and have arranged them according to their different types of dentition, as was done by Lloyd for his material. These 18 specimens are listed below :

Locality.	Sex.	Approximate body-length in mm.	Number of raptorial teeth present.	
			Left claw.	Right claw.
Station 190	♀	77·0	12	12
	♀	78·0	14	14
	♀	78·0	16	15
	♀	79·5	×	16
	♀	80·5	14	14
	♀	81·0	13	13*
	♀	82·0	11	12
	♂	73·0	15	15
	♂	78·0	12	13
	♂	78·0	17	15
	♂	80·0	12	13
	♂	82·0	13	14
	♂	83·0	12	12
	♂	83·0	14	14
Station 194	♀	78·0	×	13
	♂	77·0	13	13
	♂	101·0	15	16
	♂	105·0	14	15

Note.—Most of the specimens show a tendency (sometimes even well marked) of having some of the teeth, especially the distal ones, arranged in pairs. This has already been remarked by Lloyd.

Thus, out of the 18 specimens in the present collection 16 have the raptorial dactyli of both the sides present, while in two examples the left dactylus is missing. These 34 dactyli examined show that the number of teeth varies between 11 and 17. In the material examined by Lloyd the range of variation was from 10 to 18, but only one claw had 10 teeth, one 18 and none 11 or 12. Arranging the 16 complete specimens on the basis

* The two terminal teeth of this claw are broken, but their stumps are present.

of their raptorial teeth, as Lloyd has done, the following 11 types, somewhat different from those of Lloyd, are obtained :

Type.	Teeth present in type.		Number of individuals of the type.
	Left claw.	Right claw.	
1	11	12	1
2	12	12	2
3	12	13	2
4	13	13	2
5	13	14	1
6	14	14	3
7	14	15	1
8	15	15	1
9	15	16	1
10	16	15	1
11	17	15	1
		Total	16

Taking Lloyd's 17 specimens with the 16 complete ones in the present collection the following 18 types of variation are obtained :

Type.	Teeth present in type.		Number of individuals of the type.
	Left claw.	Right claw.	
1	10	16	1
2	11	12	1
3	12	12	2
4	12	13	2
5	13	13	5
6	13	14	1
7	14	13	1
8	14	14	5
9	14	15	1
10	15	15	3
11	15	16	1
12	16	15	2
13	16	16	3
14	16	17	1
15	17	15	1
16	17	16	1
17	17	17	1
18	17	18	1
		Total	33

It is thus seen that in a small collection of 33 individuals there are as many as 18 different types of dentition on the raptorial claw, showing the enormous variability of the

species in respect of a character that is generally very stable in the Stomatopoda. One fact that may perhaps be significant comes out of the above table and that is that a comparatively large number of individuals possess the same number of teeth on the two claws, or that the types in which the number of teeth on the two claws is the same preponderates over the types in which the number is dissimilar. Thus there are five specimens having 13 teeth on each claw, five with 14 on each claw and three each with 15 and 16 teeth respectively. There are also two examples with 12 teeth on each dactylus. The number of specimens belonging to any of the other, or asymmetrical, types is in no case more than two. Taking all the specimens that have the same number of teeth on the two claws one finds that 18 out of 33 examples, or more than half the individuals, show this symmetry of dentition. The number of specimens examined is, however, too small for any conclusions to be drawn.

Apart from the frequency of the different types of dentition on the two claws it may be useful to consider the number of teeth that occur most commonly on the individual claws. For this purpose there are 34 dactyli in the present collection that have to be considered, and these can be grouped with regard to the number of teeth present on each dactylus as in the following table :

Number of teeth.	Number of dactyli in which present.
11	1
12	7
13	8
14	8
15	6
16	3
17	1
Total	34

Taking the 34 claws examined by Lloyd also into account, the 68 dactyli thus obtained may be grouped as follows :

Number of teeth.	Number of dactyli in which present.
10	1
11	1
12	7
13	15
14	13
15	11
16	13
17	6
18	1
Total	68

It is thus seen that whereas the number of teeth on the raptorial dactylus in *S. investigatoris* varies between 10 and 18, the number of claws having 10, 11 or 18 teeth is very

small indeed, all the three groups taken together constituting less than 5% of the claws examined. The largest number of claws are with 13–16 teeth, more than three-fourths of the specimens falling in this group. Claws with 12 or 17 teeth are also fairly common. Working out the proportions for these groups the following figures are obtained :

Dactyli with 13–16 teeth constitute 76·47%.
,, with 12 or 17 teeth constitute 19·12%.
,, with 10, 11 or 18 teeth constitute 4·41%.

If the two collections, Lloyd's collection and the John Murray collection, are taken separately the percentages are slightly different.

To sum up, in *S. investigatoris*—

(1) There is an enormous range of variation in the types of dentition on the two claws ;

(2) The number of teeth on the two claws may be similar or dissimilar ;

(3) The types having the same number of teeth on the two claws seem to preponderate over types having different number of teeth ; and

(4) The number of teeth on the raptorial dactylus met with in the species varies most commonly between 13 and 16, sometimes between 12 and 17, and rarely between 10 and 18.

Squilla investigatoris does not appear to grow to a large size. The largest specimen in Lloyd's collection was 84 mm. long, while the two largest examples in the present collection measure a little over 100 mm. from the tip of the rostrum to the posterior border of the telson. There is another fragmentary individual in the collection, referred to below, that must have been about 115 mm. long.

Distribution.—So far as is known at present *S. investigatoris* has a very limited range of distribution. The type-material was collected in the Gulf of Aden, and one specimen, mentioned by Kemp, was obtained in the Persian Gulf. The present specimens are also from the Gulf of Aden, very close to the locality from which the " Investigator " material was collected. One fragmentary specimen in the present collection is from the South Arabian coast. The species, as known at present, seems to extend from the Persian Gulf, along the South Arabian coast, to the Gulf of Aden. The John Murray Expedition did not collect this species either in the Red Sea or in any other part of the Arabian Sea that it explored.

Lloyd (1908) has referred to the large numbers in which the species was found in the only locality in which the " Investigator " discovered it. The present collection does not bear this out in any very striking manner, but it is still noteworthy that 14 specimens were collected in 0·5 sq. m. of the sea floor by the grab at Station 190, and a still larger number, represented by their telsons and other fragments (*vide* p. 157, *infra*), were trawled at Station 33. The remaining species of Stomatopoda in the John Murray collection are represented in most cases by a much smaller number of specimens from any one station.

S. investigatoris is so far recorded from comparatively deep waters only. The type-material was obtained in 110 fathoms of water, while the present specimens were collected in 183 and 220 metres. The fragmentary specimen from the South Arabian coast was obtained in 102 metres, while the other fragments from Station 33 (*vide* p. 157, *infra*) came from the enormous depth of about 1300 metres. The depth at which the single specimen from the Persian Gulf, referred to above, was collected is not recorded.

There is a fragmentary specimen in the John Murray collection that is also referred to *S. investigatoris*. The anterior part of the animal is altogether missing, only the abdomen and the telson with their appendages being present. In *S. investigatoris* the raptorial claw is the most characteristic feature of the species, but a very careful examination of the parts present with similar parts of specimens in the type-series shows that the fragmentary individual is referable to Lloyd's species. The colour is considerably faded, but the general plan is almost similar to that in other specimens.

The telson is profusely pitted and the walls of the channel, formed by the row of pits on either side of the median carina becoming confluent, are broken up into distinct tubercles (see p. 152, *supra*).

Occurrence.—Station 79, South Arabian coast, 102 metres. 1 fragmentary specimen.

Judging by the size of the parts present the specimen must have been between 110 and 115 mm. long.

Squilla ? investigatoris Lloyd.

Squilla investigatoris Kemp, 1913, pp. 80–82, pl. vi, figs. 67, 68.

Occurrence.—Station 33, Gulf of Aden, 1295 metres. Fragments of a large number of specimens.

Descriptive Notes.—A large number of fragments of a *Squilla*, that I have referred to *S. investigatoris*, consisting mostly of telsons (some with the sixth abdominal somite attached), uropods and a few bits of carapace are in the collection. There are also two or three antennules and antennæ, with their scales, and a few other unrecognizable odd bits. There are no raptorial claws or other parts of the body that could help in making a definite identification. Practically no soft parts of the animals are present, and only fragments of the outer chitinous covering have been preserved. As this collection is from a great depth—probably the greatest depth from which a Stomatopod has so far been recorded—I have made special efforts to identify these fragments, as far as possible.

The few bits of carapace that have been preserved show the cervical groove deeply impressed and the carinæ distinct. The rostrum is subquadrate, with a broadly rounded apex and the sides hardly converging anteriorly. The anterior breadth of the carapace is almost half of its median length, rostrum included, as is seen from the following measurements, taken from comparatively large fragments of the carapace :

Median length of carapace, including rostrum	19 mm.
Anterior breadth of carapace	10 ,,

In the allied species *S. massavensis* Kossmann (*vide* Kemp, 1913, pp. 77, 78) the sides of the rostrum markedly converge anteriorly and the apex is less broadly rounded. The carapace is also slightly narrower at the anterior end than in *S. investigatoris*.

The sixth abdominal segment and the telson in *S. investigatoris* resemble very closely those of *S. massavensis* and some other species. In fact the resemblance is so close that on an examination of the telson alone it is sometimes difficult to distinguish examples of the present species from comparatively young specimens of *S. massavensis*. In medium-sized and large examples of the latter-named species the rows of tubercles on either side of the median carina of the telson are a very important distinguishing character, but, as already pointed out, in large-sized specimens of *S. investigatoris* also there is a tendency

towards the formation of similar tubercles. Coupled with these tubercles there are, however, two or three other characters of rather minor importance that may be of some help in recognizing the telsons of the two species. The carinæ on the marginal teeth of the telson are considerably more swollen in *S. massavensis*, especially in medium-sized and large examples, than in *S. investigatoris*, and the number of denticles, both submedian and intermediate, is generally smaller than in Lloyd's species. There are 33 telsons in the present collection and of these 29 are complete. I have examined the denticles in all these, and have found that the number of submedian denticles is in most cases 4 or 5, though really it varies between 3 and as many as 8. In the same way there are generally 9 or 10 intermediate denticles, the number varying between 8 and 11. In *S. massavensis* there are usually 3 submedian and 7–9 intermediate denticles. Further, in Kossmann's species the serration on the inner side of the longer limb of the bifurcate process of the uropod appears to be finer and more evenly arranged and extends further distally than in *S. investigatoris*. The lobe on the bifurcate process is also slightly smaller in *S. massavensis* than in the other species.

Judging by the characters enumerated above, the fragments under reference have been identified as those of *S. investigatoris*. This species and *S. massavensis* are both known to live in the Arabian Sea, but the locality from which these fragments were obtained is very close to the places from which *S. investigatoris* has been collected.

The enormous depth of 1300 metres from which these fragments were collected is very remarkable and probably constitutes a record for any Stomatopod. In view of the fact that no complete specimens were obtained, it is possible that the species does not actually live at this great depth and that dead specimens from higher levels had drifted here and their remains, mixed with mud, were dredged from this place. There are, however, a few small bits of muscles, etc., attached to the antennæ and mouth parts, etc., which might possibly indicate that the species does penetrate to this depth.

The fragments were obtained with the Agassiz trawl and the sea-bottom at this place consisted of green mud.

Squilla raphidea Fabricius.

Squilla raphidea Kemp, 1913, pp. 88–92, pl. vii, fig. 77.

Occurrence.—Station 72, Gulf of Oman, 73 metres. 1 ♂, 80 mm.

Descriptive Notes.—In the John Murray collection there is only one, rather immature specimen of this common Indo-Pacific species. As mentioned by Kemp, the rostrum in this species is rather variable. In my specimen it is unusually long, its narrowly-rounded apex going even slightly beyond the distal margin of the antennular somite ; the sides are markedly sinuous. The colour markings, mentioned by Kemp, are clearly seen; there is, in addition, a large oval patch on either side of the median carina of the carapace in front of the cervical groove. The posterior margin of the first abdominal somite is also defined by a line of dark pigment.

Distribution.—*Squilla raphidea* is a very common species all over the Indo-Pacific region and is frequently met with from Japan to the African coast. The species is not known to live in deep waters, most of the records being from depths up to 25 or 30 fathoms. Kemp (1918, p. 297) has recorded it from the brackish waters of Talé Sap in Siam also.

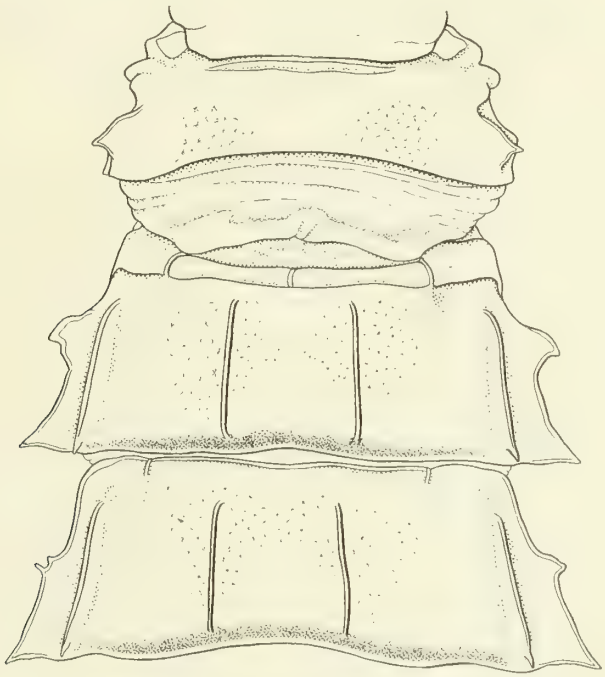
The species grows to a large size ; Kemp recorded an example from Bombay measuring 335 mm. in length.

Squilla annandalei Kemp.

Squilla annandalei Kemp, 1913, pp. 92, 93, pl. vii, figs. 78–80 ; Chopra, 1934, pp. 27, 28.

Occurrence.—Station 75, Gulf of Oman, 201 metres. 1 ♂, 123 mm.

Descriptive Notes.—A large male specimen of this somewhat uncommon species is in the collection. It agrees closely with the type-specimen in the collection of the Indian Museum in every important respect. The pigmentation of the terminal segment



Text-fig. 7.—*Squilla annandalei* Kemp. Dorsal view of fifth, sixth and seventh thoracic somites. × 4½.

of the outer uropod, the two dark spots on the telson and the transverse patch on the second abdominal somite are characteristic of this species and are clearly seen in the present example.

The tendency towards a secondary division into two lobes of the anterior lateral process of the sixth thoracic somite, remarked in 1934, is seen to a certain extent in the present example also. The anterior processes of this somite are rather broad, and somewhat more pointed than shown in Kemp's fig. 80. On the process of the left side there is a minute secondary lobe on the posterior margin ; the process of the right side is quite normal. The margin of the seventh somite on the left side also differs somewhat from Kemp's figure in having the anterior process somewhat smaller and being made up of two small lobes. On the right side the margin is normal. The exact shape of the processes on the two sides is shown in Text-fig. 7.

Distribution.—*Squilla annandalei* was so far known from the Java Sea, the Mergui Archipelago, the Gulf of Martaban and the mouth of the Hughli River ; the present record

from the Gulf of Oman in the Arabian Sea extends the range of the species very considerably westwards. All the previous records are from depths between 30 and 67 fathoms. The John Murray Expedition specimen extends the bathymetric range also to a little below the 100 fathom line.

The specimen was collected in the grab of a modified " Petersen " type and the bottom at the place of capture consisted of green mud.

Genus **PSEUDOSQUILLA** Dana.

Pseudosquilla ciliata (Fabricius).

Pseudosquilla ciliata Kemp, 1913, pp. 96–100 and 108 ; Bigelow, 1931, pp. 152–159 ; Dollfus, 1938, pp. 198–200.

Occurrence.—Station M.B. II(*a*), South Arabian coast, 11 metres. 1 ♀, 17 mm.

Descriptive Notes.—A small specimen, measuring about 17 mm. from the tip of the rostrum to the posterior extremity of the telson, belongs to what is known as the *monodactyla* stage of *Pseudosquilla*. The most striking features of this stage are the absence of distinct teeth on the raptorial dactylus, the absence of carinæ on either side of the median crest of the telson and the broadly-angled posterior margin of the telson, bearing a large number of minute denticles between the movable submedian spines.

The *monodactyla* stage of *P. ciliata* has been described in detail by Bigelow (1931). The present specimen, which is in a good state of preservation, agrees closely with Bigelow's description of the Hawaiian material. The dactylus of the raptorial limb has no teeth on its inner margin, but an examination through transmitted light reveals the rudiments of three teeth (including the apical one) under the integument. The propodus has 3 movable spines near the base, a series of 5 hairs instead of the usual pectinations and a distinct spine at the distal end, close to the articulation with the dactylus. The eyes are large and somewhat compressed laterally. The postero-lateral angles of the fifth abdominal somite are strongly spinous, but those of the fourth are only acute. The sixth abdominal somite has no intermediate spines, but the submedians and those at the postero-lateral angles are well developed. On the telson the median crest is rather low and poorly developed, and, as pointed out by Bigelow, ends in a sharp spine at a considerable distance from the margin. There are no crests on either side of the median crest. The posterior margin of the telson is broadly angled, as shown in Bigelow's figure (p. 157, text-fig. 5) and there are about 35 minute denticles, arranged like the teeth of a fine comb, between the articulated submedian spines. The 2 spines of the bifurcate process of the uropod are subequal and the inner margin of the outer spine is not markedly sinuous. The proximal segment of the exopod bears 8 movable spines on the outer margin ; Bigelow has described 9 such spines in his Hawaiian specimens, though two of his examples from Porto Rico (1901, p. 156) had 8 spines. The paddle-like distal segment of the exopod and the 2 spines of the bifurcate process extend beyond the distal segment of the exopod. There are no colour-markings in my specimen.

The *monodactyla* stage of *Pseudosquilla ornata* Miers and *P. oculata* (Brullé), species closely related to *P. ciliata*, have been described by several workers, including Bigelow

(1931, pp. 162–164 and 166, 167). A comparison with Bigelow's descriptions shows that the John Murray Expedition specimen is referable to *P. ciliata*.

The adults of the present species have been described in detail by Kemp, Bigelow and several others. Kemp and Dollfus have given detailed synonymies of the species and the latter has added a list of records of its occurrence in the Red Sea.

Distribution.—*P. ciliata* has an extremely wide range of distribution, being one of the very few Stomatopods that live both in the Atlantic and the Indo-Pacific region. Kemp has given a long list of localities in both these areas where the species has been found.

The species lives in shallow waters only and is very abundant in coral reefs, oyster beds and other similar places. The present specimen was dredged at a depth of 11 metres, and the bottom at the place of capture consisted of coarse sand.

Bigelow believes that in the *monodactyla* stage *P. ciliata* and some other species inhabit the bottom during the day and swim near the surface at night.

Genus **LYSIOSQUILLA** Dana.

Lysiosquilla maculata (Fabricius).

Lysiosquilla maculata Kemp, 1913, pp. 111–116, pl. viii, figs. 86–91 ; Bigelow, 1931, pp. 169–173 ; Chopra, 1934, pp. 28–30.

Occurrence.—Extra Station, Aden Harbour, surface. 1 ♀, 156 mm.

Descriptive Notes.—The coloration of the John Murray Expedition specimen is very much like that shown in Kemp's fig. 88. There is one important character in which the present example differs from Kemp's detailed description, as also from all the other specimens of the species that I have seen. In *L. maculata* the dactylus of the raptorial claw bears on its inner margin 9–11 teeth, including the terminal one, the usual number being 10 and somewhat rarely 9. In the present specimen both the dactyli have 12 teeth each. The first or the proximal tooth is minute, but can be clearly seen even without a lens. So far as I am aware, 12 teeth on the raptorial dactylus have not been hitherto recorded in this species. All the teeth are slender and, as usual, are minutely serrated on both the margins. The terminal tooth is twice the length of the one preceding it. The dactylus is straight on the outer border, the breadth of the propodus is a little less than one-fourth of its length and there are 4 movable spines at its base ; the claw is of the male type, as described by Kemp.

As remarked by Kemp and Bigelow the eyes are proportionately small in large females. The present specimen also shows the same feature.

Total length	156 mm.
Median length of carapace	27·5 mm.
Breadth of cornea	6·3 ,,
Corneal index	4·3

Distribution.—*Lysiosquilla masulata* has a very wide range of distribution over the Indian Ocean and the Indo-Pacific region. It extends from Japan and Oceania on the east to as far west as the African coast. Kemp and Bigelow have recorded a large number of localities from which the species has been obtained. As mentioned by these authors,

the species has been met with in the Atlantic also, but seems to be very scarce there. Further, as pointed out by Bigelow, the specimens recorded from the Atlantic are not quite typical.

The species occurs in shallow waters only. Bigelow states that it is so abundant in Honolulu that it forms the object of a fishery.

L. maculata grows to a large size ; a male specimen 315 mm. long has been recorded.

Lysiosquilla multifasciata Wood-Mason.

Lysiosquilla multifasciata Wood-Mason, 1895, pp. 1, 2, pl. i, figs. 4–7 ; Kemp, 1913, pp. 122–124 ; Kemp, 1915, pp. 175, 176, pl. i, figs. 2, 3 ; Schmitt, 1922, pp. 144–146, pl. xix, figs. 15–18 ; Dollfus, 1938, pp. 203, 204.

Occurrence.—Station 72, Gulf of Oman, 73 metres. 5 ♂♂, 4 ♀♀, 41–64 mm.

Descriptive Notes.—The John Murray Expedition collected a fine series of nine specimens of the present species. There are, however, only three specimens in which the raptorial claws are present ; of these, two males (45 and 64 mm. long) have only one claw each, while a large female, measuring 56 mm. in body length, has both the claws present. Two of the specimens are damaged, a large female (about 58 mm.) having the body badly crushed about the middle of the abdomen, and a male (53 mm.) with the telson and one or two posterior abdominal somites injured.

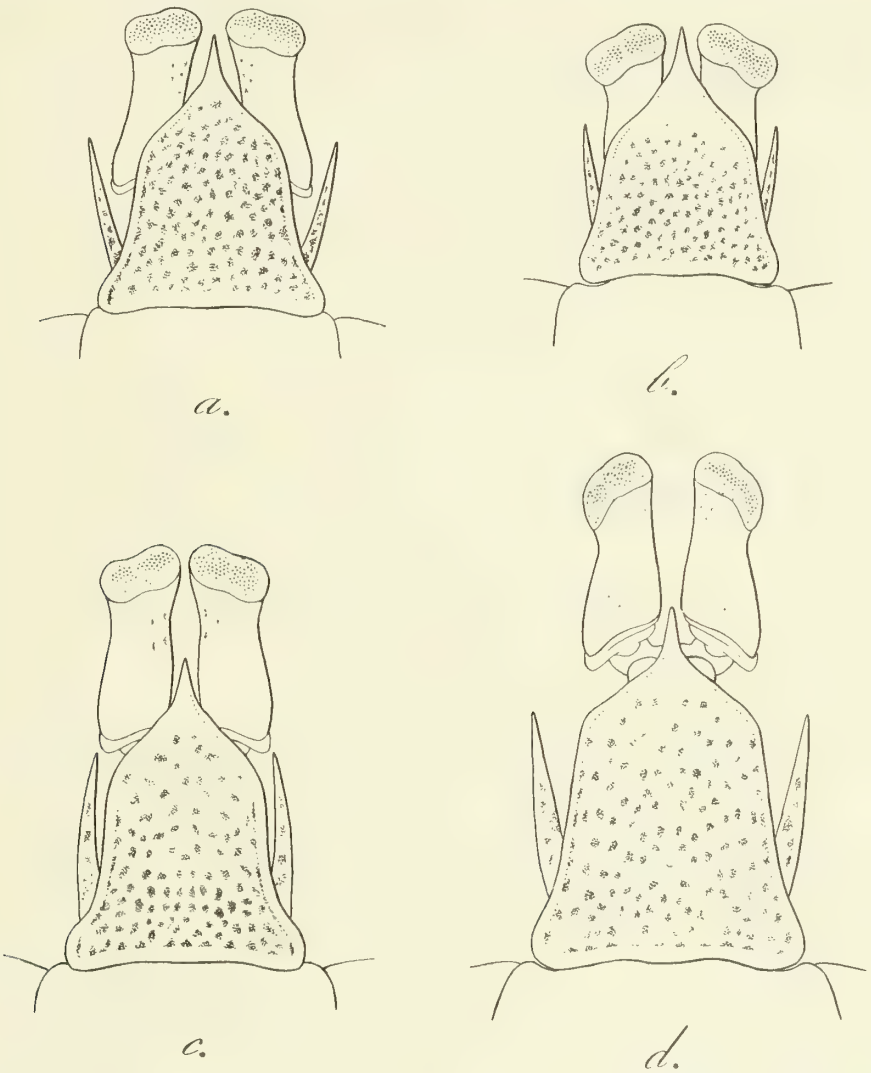
The colour pattern on the dorsal surface of the body agrees on the whole with that of the type, and some of the variations mentioned by Kemp (1915) are also seen in several examples. The two anterior bands of the carapace are faintly visible in two or three specimens only, but the posterior band is distinctly marked in all the examples. In most cases the anterior two-thirds of the carapace is covered by a large patch of pigment, and even where the anterior bands can be distinguished separately, they do not extend to the margins of the carapace. In most of the specimens the narrow anterior abdominal bands can be made out more or less clearly, and, as described by Kemp, are connected to the broad posterior bands mid-dorsally by a diffusion of pigment. In all the present examples the pigmentation is very much fainter than in the type-specimen, even though the latter has been preserved in spirit for a long time.

In structural characters also the Arabian Sea specimens resemble the type closely. The species is very easily recognized, among other characters, by the presence of two greatly unequal lobes near the base on the external margin of the raptorial dactylus.

The present specimens show interesting variations in two or three characters. The cornea of the eye is somewhat smaller than in the type-specimen, or in the two examples from the Philippines (Kemp, 1915) in the collection of the Indian Museum, and, whereas it is cylindrical in the three latter specimens, in the Arabian Sea material it is distinctly flattened and shows a tendency of being bilobed. This flattening and a tendency towards bilobing is slightly visible in the larger of the two Philippine examples also, but it is more marked in the present specimens.

In the three Indian Museum specimens that I have examined the rostrum covers the basal third of the eye-stalk, and the spine-like rostral tip extends to about the base of the cornea. In the specimens from the Gulf of Oman the condition varies a great deal. In a male specimen (45 mm.) the condition, as seen in Text-fig. 8, *a*, is more or less typical, as described by Wood-Mason ; in another male (53 mm.), though the tip reaches up to the

base of the cornea, the rostrum covers considerably more than a third of the eye-stalk. In four examples (one male 53 mm., and three females 41, 45 and 58 mm.) the rostrum covers the greater part of the eye-stalk and the rostral tip goes up to the end of the cornea, or even a little beyond it (Text-fig. 8, *b*). In the remaining three specimens the condition is still more interesting. In one large male (59 mm.) the rostrum covers only a very small



TEXT-FIG. 8.—*Lysiosquilla multifasciata* Wood-Mason. Dorsal view of rostrum, eyes and dorsal processes of antennular somite of : (*a*) a male, 45 mm. ; (*b*) a female, 45 mm ; (*c*) a male, 59 mm. ; (*d*) a male, 64 mm. All × 10.

basal portion of the eye-stalk and the tip hardly extends to the middle of the stalk (Text-fig. 8, *c*) ; in the remaining two examples, a female (56 mm.) and a male (64 mm.) the rostrum does not even reach the base of the eye-stalk, the whole of which is left uncovered, and the tip barely extends a little beyond the base (Text-fig. 8, *d*). The eye-stalks are fairly well extended in all the specimens. The rostrum is typical except that the angles between the basal and the apical portions are more obtuse than shown in Wood-Mason's figure of the type. The spine of the rostrum is considerably shorter than the basal portion or the dorsal processes of the antennular somite. This is the condition in the type also,

but in the example described by Schmitt the rostral spine appears to have been much longer.

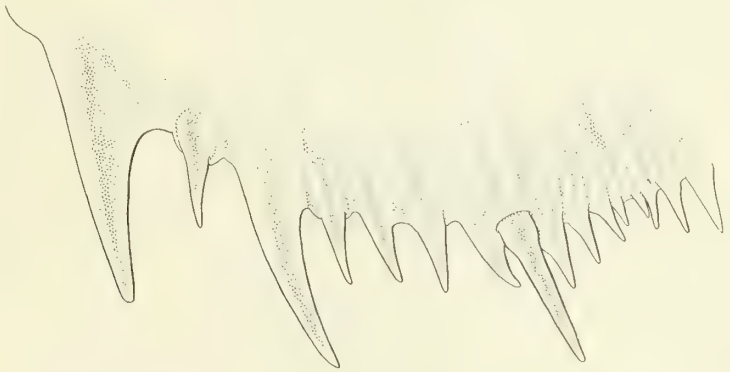
The raptorial dactylus has, on its outer margin, the two lobes characteristic of the species, the distal lobe being very much larger than the proximal. As already stated, there are only four raptorial claws present in my collection, and in all the four of them the dactylus is furnished with 6 teeth on the inner margin. The first, or the proximal, tooth is small in all the cases, and in the small male (45 mm.) it is minute. In the Philippine material examined by Kemp the larger examples had only 5 teeth on each dactylus, the younger 6 ; the first tooth was small in every case and placed very close to the next. In my specimens, as in the type, the first small tooth is not particularly close to the second. The antepenultimate tooth is always longer than the penultimate. The carpus has a large overhanging spine on its dorsal aspect.

Schmitt has laid considerable emphasis on the number and sizes of the various denticles between the spines or teeth on the posterior margin of the telson. Between the movable submedian teeth there are, in the type-specimen, 4 pairs of short denticles ; these are evenly placed and somewhat increase in size from the innermost to the outermost pair. In the Philippine examples Kemp found 3 or 4 pairs ; in the large Philippine specimen* in the Indian Museum there are 3 pairs, while in the smaller one there are 4. In his Chinese specimen Schmitt found only 3 paris of denticles, distinctly increasing in size from the innermost to the outermost pair. In the John Murray Expedition material there are 4 pairs, the innermost of which are minute, and the other pairs progressively increase in size towards the outermost. Seen from the ventral side the posterior margin of the telson is slanting upwards from the median line to the submedian spine of either side, and as the submedian denticles are placed on this sloping surface, they do not all arise at the same horizontal level, those of the innermost pair being distinctly more dorsally placed than the denticles of the next pair, and thus being partly hidden by them in ventral view. By examining the specimen in a slightly oblique view, either from above or from below, all the 4 pairs of denticles can be easily made out. In two examples one of the minute denticles of the innermost pair is broken on one side, leaving a microscopic stump, but on the other side the full complement of 4 denticles is present. There are invariably 4 denticles between the submedian and the intermediate spine of either side. According to Schmitt, the first and the third denticles, counting from the inner side, are the smallest, the second is the largest, while the fourth is intermediate in size between the second and the first or third. The large Philippine example that I have seen conforms to this description ; the type-specimen also more or less agrees with it. In the John Murray Expedition specimens the size-variation of the intermediate denticles is not very clearly seen, but generally the second denticle, again counting from the inner side, is slightly larger than the others. In some cases the first and the second denticles are subequal and larger than the third and fourth. The exact arrangement and sizes of the various denticles in a large specimen from the Gulf of Oman are shown in Text-fig. 9. In the

* Only two pairs of submedian denticles are seen in Kemp's figure (1915, pl. i, fig. 3) of a large Philippine specimen, for the reason that the overhanging median tooth on the dorsal surface of the telson conceals, in a dorsal view, the two innermost denticles. In our large Philippine specimen also only two pairs of submedian denticles can be seen from above, but seen from the ventral surface, or in a slightly tilted position from above, all the three pairs can be easily made out. Schmitt mistook the submedian spines for the outermost denticles.

figure given by Dollfus also the sizes of the different denticles are not quite as described by Schmitt. As usual there is only one lateral denticle ; the larger Philippine example in the Indian Museum collection differs from all the other specimens that I have seen in having a small additional lateral denticle on the left side of the telson. On the right side there is only one denticle.

Distribution.—*Lysiosquilla multifasciata* was described by Wood-Mason from a single female specimen from Bombay. The species has a wide range of distribution over the Indo-Pacific region, extending from Japan to the Red Sea. It has been recorded from Japan (Komai, 1927), Formosa (Balss, 1910), Amoy on the Chinese coast (Schmitt, 1929), Philippine Islands (Kemp, 1915), Borneo (Nobili, 1903), and the Red Sea (Nobili, 1906; Tattersall, 1921; and Dollfus, 1938). Kemp has doubted the correctness of Nobili's records from the last two localities, chiefly for the reason that Nobili has not mentioned the two greatly unequal lobes on the outer margin of the raptorial dactylus, which is undoubtedly the most important structural character of the species. His description of



Text-fig. 9.—*Lysiosquilla multifasciata* Wood-Mason. Margin of the telson, showing the marginal spines and denticles of one side, seen a little obliquely from below. × 15.

the Red Sea specimens at least seems to indicate that he was dealing with the present species. It is noteworthy that in the length of the rostral spine and the position of the two innermost denticles between the submedian spines of the telson Nobili's Red Sea examples showed the same variation as has been noticed in the Gulf of Oman specimens. Also later records show that the species undoubtedly lives in the Red Sea. The presence of only 4 submedian denticles (instead of 6 or 8) in one of Nobili's specimens is unaccountable.

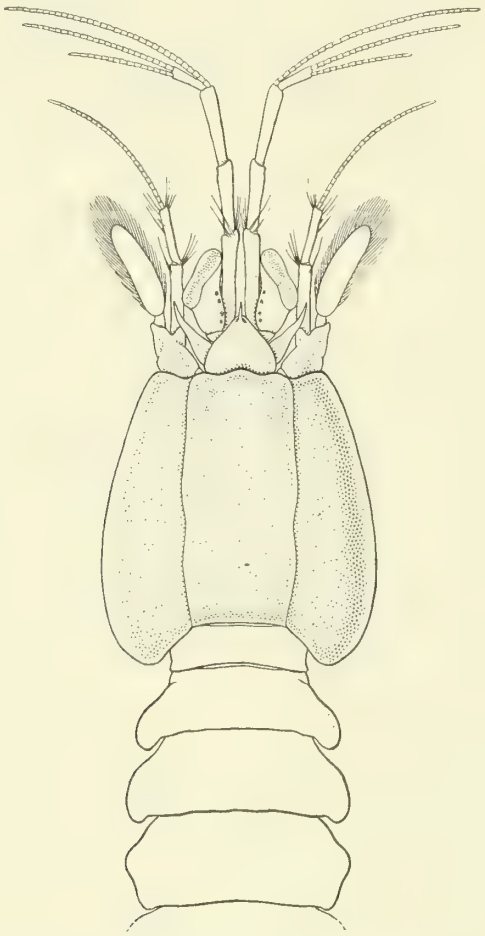
The species appears to be an inhabitant of shallow waters only. All the specimens that had hitherto been known were probably collected near the shore, though the exact provenance of some of them has not been recorded. The present examples were obtained at a depth of 73 metres, which is probably the greatest depth at which the species is so far known to live. The species seems to prefer a bottom of sand, and has been collected in some cases with *Balanoglosus* ; in the present instance the bottom consisted of coarse sand and shells.

L. multifasciata does not grow to a large size ; the largest specimen so far collected is probably the 64 mm. long male in the present collection. Kemp's largest example from the Philippines was only 56 mm. long.

Lysiosquilla sewelli, sp. nov.

Occurrence.—Station 176, Gulf of Aden, 695 metres. 1 ♀, 42 mm. Type.
Station 194, Gulf of Aden, 220 metres. 1 ♂, 32 mm.

Descriptive Notes.—The dorsal surface of the animal is smooth and polished. The carapace (Text-fig. 10) is without any carinæ, and is narrowed anteriorly. The antero-lateral angles are rounded, while the postero-lateral are produced backwards as broad, rounded lobes, extending considerably behind the posterior margin of the carapace. The



Text-fig. 10.—*Lysiosquilla sewelli* sp. nov. Carapace and exposed thoracic somites, dorsal view. × 4½.

length of the carapace in the median line is almost equal to its greatest breadth, which is a little in front of the posterior end. The gastric grooves are sharply marked from end to end, but the cervical groove is obsolete and its position is only faintly indicated by the vestige of a shallow depression on the outside of the gastric groove.

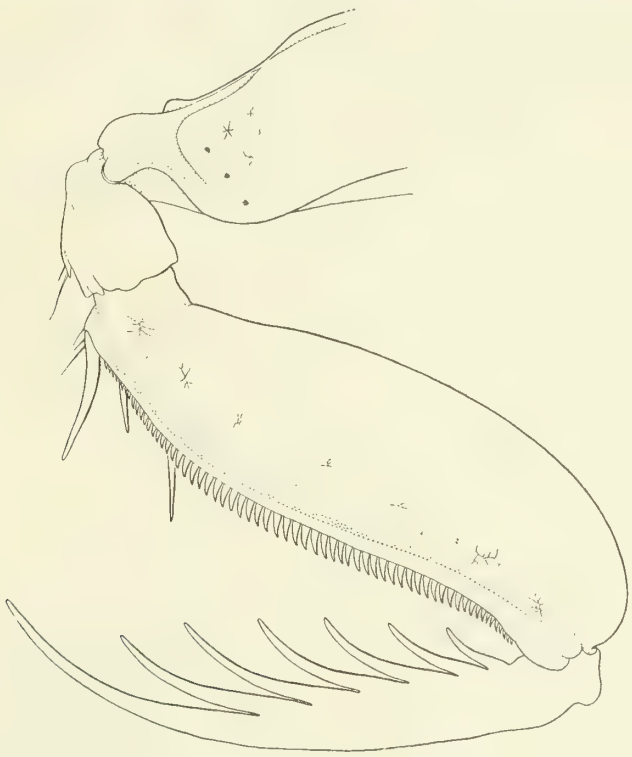
The rostrum is triangular in shape, with rounded sides, and the apex terminating in a sharp spine. Its length, including the spine, is almost equal to its breadth, a little in advance of the base. There is no carina on the rostrum and its surface is smooth.

The eyes are large, the breadth of the bilobed cornea being slightly more than the median length of the stalk and cornea combined. The corneal axis is obliquely placed to

the peduncular axis. The ophthalmic somite is completely hidden by the rostrum, and the shape of the dorsal processes cannot be made out in dorsal view.

The antennular peduncle is long, being hardly shorter than the median length of the carapace, excluding the rostrum. The dorsal processes of the antennular somite are large, horn-like structures, sharply pointed at the tip, and anteriorly reaching up to the cornea. The antennal scale is short and is less than half the median length of the carapace, The mandibular palp is well developed and composed of three segments.

The raptorial claw (Text-fig. 11) does not present any unusual features. The merus is longitudinally grooved ventrally and the outer inferior margin is broadly rounded distally. The carpus has a sharp dorsal carina, which terminates in an acute spine before



TEXT-FIG. 11.—*Lysiosquilla sewelli* sp. nov. Terminal portion of raptorial claw. × 10.

reaching the distal margin. The propodus is a little more than three times as long as broad ; the external margin in contact with the dactylus bears a series of rather long and closely-set pectinations, while at the proximal end of the internal margin there are 3 movable spines. The middle one of these spines is the smallest, and the most distal one is placed at a little distance from the other two. The dactylus is rather slender, and on its outer margin, at the basal end, there is a small lobe, followed by a rather deep concavity. There are 7 teeth, including the one at the apex, and these gradually increase in size from the proximal to the distal end.

The appendages of the third thoracic segment are distinctly longer than those of the fourth and fifth, which are subequal. The hands of the third and fourth legs are oblong in shape, that of the third being about twice as long as broad. The hand of the fourth leg is distinctly shorter and only slightly broader than that of the preceding appendage and is about one and a half times as long as broad. The hand of the fifth leg is also longer

than broad and is quadrate in shape, the distal border being somewhat longer than the proximal; it is as broad as the hand of the fourth appendage, but is slightly shorter. There is a thick tuft of hairs along the distal border. The ischium of the fifth leg is carinate along the inner border of the lower surface and ends in a minute spine at the distal end. An epipodite is present at the base of each of the first five thoracic appendages; in the type-specimen the epipodite of the raptorial claw of one side and of the fifth leg of the other side is missing, but the full complement of 5 epipodites is present on both sides in the other specimen.

There are no carinæ on the exposed thoracic somites. The lateral margin of the fifth thoracic somite is obscurely notched into two lobes, the anterior of which is bluntly rounded, and the small posterior one is somewhat sharply pointed. The margins of the sixth and seventh somites (Text-fig. 10) are produced posteriorly into a rounded lobe each. The eighth thoracic somite is the largest and its lateral margins are bluntly pointed in the middle.

The shorter ramus of the last 3 thoracic limbs is linear.

The abdomen is depressed and is, for the most part, smooth and shining. There are a number of fairly distinct longitudinal carinæ on most of the abdominal somites (Text-fig. 12, *a*, *b*). The marginal carina is present on the first 5 somites, though on the first, and to a certain extent on the second also, it is rather low and indistinct. The lateral carina is present on segments 4, 5 and 6, the intermediate on 5 and 6, while the submedian can be seen only on the sixth. Some of the carinæ on the sixth segment show a tendency of being broken up into tubercles or short carinæ. The carinæ on some of the segments end in distinct spines, the spine-formula being as given below:

Carinæ.	Abdominal somites.
Marginal	3*, 4
Lateral	4, 5†, 6
Intermediate	5, 6
Submedian	6

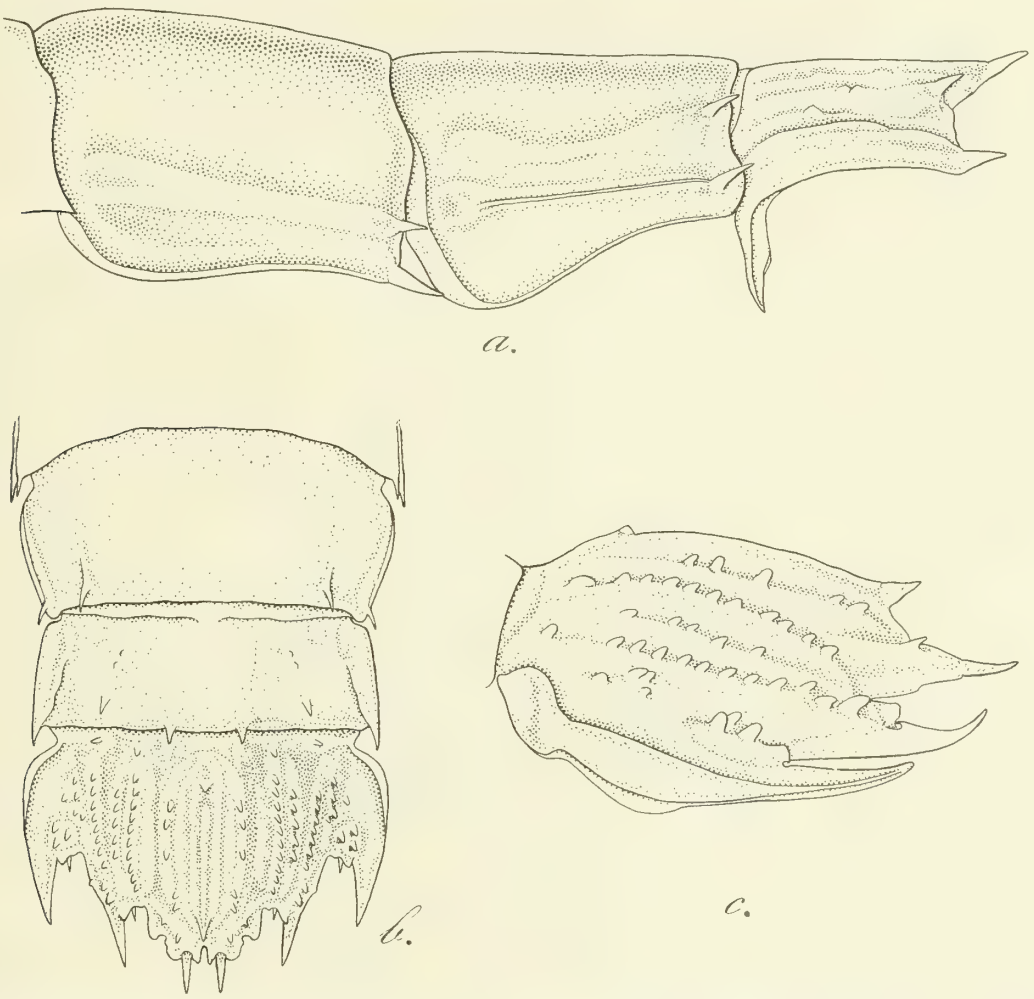
The sixth abdominal segment is short, being about three-fourths as long as the fifth. On its dorsal surface it bears 3 pairs of carinæ. The lateral carinæ, which are bifurcated near the base, appear to be fused with the marginal; the intermediates are somewhat broken up into tubercles; while the submedians are very short, and are clearly visible for a little distance only near the posterior margin. There are also a few scattered tubercles on this segment. Near the posterior margin there are 6 spines terminating the 3 pairs of carinæ; of these the intermediates arise a little in advance of the margin. The antero-lateral angle of this segment bears a long, sharp hook-like spine on the ventral surface. This spine is directed downwards and is prominently seen in a lateral view (Text-fig. 12, *a*).

The telson (Text-fig. 12, *b*, *c*) is a little less than twice as broad as long and is markedly convex above. The dorsal surface is ornamented with a number of longitudinal carinæ, most of which are broken up into tubercles. The median carina is greatly elevated and is entire; it terminates at its distal end in a sharp overhanging spine, and has another

* The marginal carinæ on the third segment end in acute angles rather than sharp spines.

† The marginal and lateral carinæ of the fifth somite, as seen in a dorsal view (Text-fig. 12, *b*), lie close to one another, but the lateral only ends in a spine. This is clearly seen in a lateral view (Text-fig. 12, *a*) in which the two carinæ appear well separated.

blunt, spine-like elevation near its proximal end. The only other carina that is entire is a little on the inside of the large lateral spine of the telson. Proximally it is at a little distance from the margin of the telson, but running obliquely outwards it comes to lie very close to the spine in its distal portion. On each side of the median carina, and running parallel to it, there is a longitudinal row of tubercles. There are three more broken carinæ or rows of tubercles on each side, almost opposite the intermediate teeth or spines of the telson. The innermost of these reaches the posterior margin a little on the inside of the



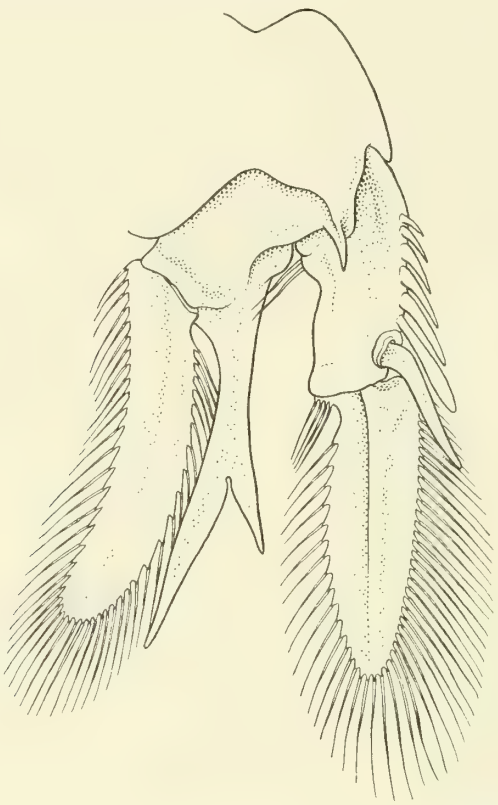
Text-fig. 12.—*Lysiosquilla sewelli* sp. nov. (*a*) Last three abdominal somites, lateral view. × 12. (*b*) Last two abdominal somites and telson, dorsal view. × 6. (*c*) Telson, lateral view. × 12.

marginal tooth; the next is short and does not reach the posterior margin; while the outermost of these reaches the posterior margin at the base of the intermediate tooth. Opposite the cleft between the intermediate and the lateral marginal teeth there are some tubercles, more or less arranged in lines. The three pairs of marginal teeth are long and are strongly developed. The submedians are mobile and the intermediates and laterals are upturned at their tips. The margin of the telson is somewhat deeply cleft between the submedian spines, and is lobed on either side between the submedian and the intermediate spines. There is a lobe at the base of lateral spine also. There are no submedian denticles, but there is one intermediate and one lateral denticle on each side, arising in

the usual manner on the ventral surface, and quite close to the lobes at the base of the spines.

The ventral surface of the telson is smooth and, except for the 2 pairs of minute denticles, which, as mentioned above, arise from the ventral surface close to the margin, there is no armature of spines or keels. The anus is slightly raised.

The peduncular segment of the uropod (Text-fig. 13) has a large overhanging carina along the outer aspect of the dorsal surface and a prominent spine at the distal end of the inner margin. The bifurcate process of the basal segment of the uropod is rather narrow and is quite smooth on its inner margin, and of the 2 spines the inner is more than twice as long as the outer. The proximal segment of the exopod has a large fixed spine



Text-fig. 13.—*Lysiosquilla sewelli* sp. nov. Right uropod. × 12.

on the lower surface at the distal end, and 7 movable spines on its outer border. These spines increase in size from the proximal to the distal, and the last of these does not reach to the middle of the distal segment of the exopod. The distal segment is ribbed in the median line.

The foregoing description is chiefly based on the large female specimen from Station 176 ; this specimen is considered the type. The smaller male also resembles it very closely. The only appreciable difference between the two, apart from coloration, which is described below, is that the carinæ of the telson in the smaller specimen are not quite as well developed as in the type. The general plan of armature is identical in the two, but the carinæ are feebler, and the short row of tubercles between the two long intermediate rows is somewhat indistinct. These differences may possibly be due to the small size of the male.

Some measurements, in millimetres, of the two specimens are given below :

	Female from Station 176.	Male from Station 194.
Total length of body	42·0	32·5
Median length of carapace, excluding rostrum	7·3	5·8
Anterior breadth of carapace	5·5	4·5
Greatest breadth of carapace	8·3	6·3
Median length of fifth abdominal somite	4·2	3·1
,, ,, of telson, excluding submedian spines	5·0	4·0
Greatest breadth of telson	8·3	6·8

The type-specimen is whitish in colour, and has practically no pigmentation. On the inside of the eye-stalk there are five or six small, dark violet spots, and on the outside of the merus of the raptorial claw near its distal end there are four or five similar, but fainter spots. The spinules and tubercles on the telson are shining. The smaller male example has a distinctive colour-pattern. The ground colour is white, as in the female, but there is a profuse mottling of a brownish-orange colour. The antennular peduncle has a few spots of this tint, while the second segment of the antennal peduncle has a large patch. The dorsal surface of the eye-stalk has a large number of small spots of orange, and there is a diffusion of the same pigment on the rostrum and the carapace. On the latter there are also two more or less distinct streaks running longitudinally on the inside of the gastric grooves, and an aggregation of spots on the mid-dorsal region and another close to the posterior margin. In addition to diffused mottling, the merus of the raptorial claw has a large patch of brownish-orange on its outer surface, near the distal end, and a similar, but smaller patch is present on the carpus also. All the thoracic and abdominal somites are profusely mottled, besides each having a darker band close to the posterior margin. The telson has less of this mottling than the rest of the body. The basal segment of the uropod has also some streaks of pigment.

Distribution.—*L. sewelli* is so far known from the Gulf of Aden only, having been collected by the John Murray Expedition from two stations very close to one another in this area. The type-specimen was collected at a depth of 695 metres, while the other example was obtained in 220 metres of water. The sea-bottom at the place where the type was collected consisted of green mud and sand.

The determination of the exact systematic position of the species described above has been a matter of considerable difficulty and doubt. The species appears to combine the characters of a number of different genera, namely, *Lysiosquilla* Dana, *Pseudosquilla* Dana, *Squilla* Fabricius and *Coronidopsis* Hansen. In the loosely articulated and depressed abdomen the species presents the general appearance of a *Lysiosquilla*; the rostrum, carapace and the raptorial claws are also typical of this genus. The presence, on some of the posterior abdominal somites, of longitudinal carinæ, some ending in distinct spines, is a character very rarely met with in the genus *Lysiosquilla*; it is a characteristic feature of *Squilla*. Similarly the telson with the median carina strongly developed and an elaborate armature of broken longitudinal carinæ and spinule-like tubercles on the dorsal surface is more like that of *Pseudosquilla*, than of the species either of *Squilla* or *Lysiosquilla*. In *Pseudosquilla* the raptorial dactylus, however, is not known to have more than 3 teeth on its inner edge; in the present species there are 7, as is the case in some species of the genera *Squilla* and *Lysiosquilla*. With *Coronidopsis*, of which only one species is so far known, *L. sewelli* shows a fairly close general resemblance, but

in Hansen's genus, among other characters, the rostrum is of a very peculiar shape, no well-marked carinæ are present on the posterior abdominal somites (though some spines, more or less like those in my species, have been described by Hansen), and the under-surface of the telson is elaborately armed with spines and keels. I have mentioned here only a few important characters for comparison, but there are several other features also in which the present species shows its peculiarity.

In the genus *Lysiosquilla* I am not aware of any Indo-Pacific or Mediterranean species that shows any close resemblance with the present species. The only possible exception to this statement is the species described by Kemp (1913, pp. 126–128, pl. ix, figs. 99–102) under the name *L. insignis*. In this species there are some traces of longitudinal carinæ on the last two abdominal somites and some distinct carinæ are present on the telson also. There is, however, no median carina on the telson and there are also several other equally important differences between the two. The only near relations of *L. sewelli* that I can find are the two forms provisionally described by Bigelow (1901) from Porto Rico in the Atlantic under the names *L. plumata* and *L. maiaguesensis*. In these species, especially the latter, among other characters, the marginal and some other carinæ are present on the abdominal somites, the last of which has 6 spines on its posterior border and, in addition to the narrow lateral marginals, there are 3 distinct carinæ, including the median one, on the dorsal surface of the telson. The general resemblance between these two species, on the one hand, and the Arabian Sea form, on the other, is quite close. In Bigelow's species, however, there are fewer and less well-developed carinæ and fewer spines on the abdominal somites, and on the dorsal surface of the telson there are 3 distinct carinæ, instead of the elaborate armature that is present in *L. sewelli*. There are also several other specific differences between the two. It is noteworthy that Bigelow also remarked on the *Pseudosquilla*-like telson in at least one of his species.

It seems to me probable that *L. sewelli* and the two Porto Rico species represent a very specialized group within the genus *Lysiosquilla*, even more so than the group comprised by *L. insignis* Kemp and *L. latifrons* (de Haan), mentioned by Kemp (1913, p. 110). The first three species show some affinity to *L. insignis* on account of the fact that in all of them at least traces of longitudinal carinæ, some ending in spines, are present on the dorsal surface and the submedian teeth of the telson are mobile in all. In its sixth abdominal segment and telson *L. spinosa* (Wood-Mason) (see Kemp, 1913, pp. 118–120) also shows some slight resemblance to this group and may perhaps be a connecting link between it and the more typical species of the genus, but the peculiar shape of the ventral process of the uropod in Wood-Mason's species is a feature that is not met with in any other species of *Lysiosquilla*.

The only species of *Lysiosquilla* recorded by Kemp as occurring in depths of more than 100 fathoms are *L. insignis* and *L. maiaguesensis*—both these species, as discussed above, show some resemblance with *L. sewelli*.

Genus **GONODACTYLUS** Latreille.

Gonodactylus demani Henderson var. **spinosus** Bigelow.

Gonodactylus demani var. *spinosus* Kemp. 1913, pp. 165 and 198, 199 pl. ix, fig 122.
Gonodactylus demani var. *spinosus ?* Kemp and Chopra, 1921, pp. 309–311.
Gonodactylus spinosus Bigelow, 1926, pp. 579–582.
Gonodactylus De Mani var. *spinosus* Dollfus, 1938, pp. 215–217.

Occurrence.—Station B [? M.B. I(*b*)], Red Sea, 29 metres. 1 ♂, 18 mm.

Station M.B. I(*d*), Red Sea, 26 metres. 1 ♂, 22 mm.

Station 37, Gulf of Aden, 18–22 metres. 1 ♀, 28 mm.

General Discussion.—Hansen (1926, pp. 26–29) is of the opinion that *G. demani* is only a variety of the common Indo-Pacific *G. chiragra* (Fabr.). The latter species, as is well known, is extremely variable, especially in some characters of the telson, and it is often a matter of considerable difficulty to name young specimens of the *chiragra* group with any confidence. The variability, especially in young specimens, is so great that Lanchester, Borradaile and several other carcinologists have set up a large number of varieties of *G. chiragra*; this question has been very ably discussed by Kemp (1913). The three keels on the mid-dorsal portion of the telson may be sharp or rounded and may be moderately or markedly convex in a lateral view. The surface of the telson is generally smooth in typical examples of *G. chiragra*, but, as Hansen has shown, a few sharp spinules may be rarely present near the posterior end of the keels. In *G. demani* the surface is generally covered with spinules profusely, but sometimes the spinulation is only moderate to scanty, and in Borradaile's (1898) *G. espinosus*, which Kemp regards as a variety of *G. demani*, the surface is said to be quite smooth. The same variability is seen in the length and distinctness of the intermediate and lateral marginal teeth of the telson and to a certain extent in the relative length and breadth of the telson. Similarly, in typical examples of *G. chiragra* the keels on the submedian and intermediate teeth of the telson are usually sharp and distinct, but Hansen has described certain specimens in which these keels are rounded, more or less as in *G. demani*. Kemp has mentioned the dorsal processes of the ophthalmic somite as another character useful for separating *G. demani* from *G. chiragra*; this character, though certainly useful in a general way, cannot be relied upon, as Hansen has also stated, in the case of young individuals to the extent that Kemp has suggested.

I have, however, preferred to follow Kemp and some later workers in regarding *G. demani* as a distinct species, rather than a variety of *G. chiragra*. In Henderson's species the dorsal surface of the telson, with the enormously swollen keels separated from one another and from the rounded keels on the submedian and intermediate marginal teeth by narrow V-shaped grooves, presents a facies that can be scarcely confused with that of the telson of *G. chiragra*. The figures given by Kemp (1913, pl. ix, figs. 109–112) and Dollfus (1938, p. 214, fig. 16, p. 216, fig. 17) clearly show the appearance of the telson in *G. demani* and its varieties.* I have examined a number of very young examples of *G. chiragra* in the collection of the Indian Museum and the telson generally presents a sufficiently different appearance from that of same-sized specimens of *G. demani* to render the recognition of the two species possible. The median keel is extremely convex in lateral view, considerably more so than in any of the very large number of specimens of *G. chiragra* that I have examined. I have seen no specimen of *G. chiragra* with spinules on the dorsal surface of the telson. Another very important and constant character that marks off *G. demani, forma typica*, from *G. chiragra* is the absence, in the former, of setæ on the inner margin of the endopodite of the uropod. There are, however, varieties of *G. demani* in which this character does not hold good. Lastly in large examples at least the dorsal

* The figures given by Gravier (1935) do not appear to be those of *G. demani* and certainly not of the *forma typica*. There are wide spaces between the keels on the telson and the inner margin of the endopod has a fringe of setæ.

processes of the ophthalmic somite are much smaller in *G. demani* than in specimens of the same size in the other species. *G. demani* is also a much smaller form than *G. chiragra*; I have seen several specimens of the former species well under 30 mm. in length with their eggs.

Hansen has also discussed the question of the presence or absence of spinules on the telson of his *G. œrstedi*—a species that replaces *G. chiragra* in the Atlantic and is found in certain parts of the Pacific also. In Hansen's species such spinules are, as a rule, absent, but in several examples examined by him a few spinules have been noticed and Nobili has even given a separate specific name for such spinule-bearing forms. Bigelow (1931), who has also discussed the question of the different species and varieties in the *chiragra* group at some length, considers Nobili's *festæ* as a variety of *G. œrstedi*; he has also included another spinule-bearing form as a variety of Hansen's species. On the analogy of *G. œrstedi*, Hansen has argued that the form of *G. chiragra* bearing spinules on the telson cannot be recognized as a distinct species. It is thus seen that in *G. œrstedi* and, to a certain extent, in *G. chiragra* also there is a gradual transition from smooth forms to forms bearing spinules on the telson; similarly (as remarked by Kemp and Bigelow) in *G. demani* also a transition from forms that are profusely spinulate to forms that are almost or quite smooth can be traced. This character—the presence of spinules on the telson—seems to have been evolved in these three species independently and along parallel lines.

Hansen has discussed another interesting question, namely, the presence, in his specimens of *G. demani*, of a longitudinal "impression" on the "intermediate" dorsal carina of the telson, nearly dividing each carina into two parallel keels. This indicates a transition to a condition in which five keels are normally present on this part of the telson, as, for example, in *G. glabrous* Brooks (*vide* Kemp, 1913, pp. 167–169, and Bigelow, 1931, pp. 127–135). Lanchester (1903) had already suggested such a transition and had in fact regarded *G. glabrous* only a variety of *G. chiragra*, but, as shown by Kemp and Bigelow, *G. glabrous* certainly deserves specific rank. In one or two specimens in the John Murray Expedition collection that have been provisionally referred to Borradaile's variety *espinosus* of *G. demani* (*vide* p. 178, *infra*) a shallow longitudinal groove, somewhat similar to the one described by Hansen, has been seen.

The *chiragra* group of *Gonodactylus* is thus seen to be a very homogeneous one, and the limits between the different species and varieties are sometimes not well defined. *G. chiragra*, the parent form, like several other members of the group, is exceedingly variable, and a large number of varieties have been described, but Kemp has, in my opinion rightly, merged most of them with the *forma typica*, recognizing only Wood-Mason's *platysoma* (see also Bigelow, 1931) as a valid variety. In the Atlantic and in certain parts of the Pacific *G. chiragra* is replaced by Hansen's *G. œrstedi*, which is characterized by the presence of an additional keel on the inside of the keel on the intermediate marginal tooth of the telson. *G. œrstedi* also shows considerable variation in the matter of spinules on the telson, and two varieties, *festæ* Nobili and *spinulosus* Schmitt (*vide* Bigelow, 1931, pp. 123, 124), based at least partly on this character, have been recognized. *G. demani*, the other very near relation of *G. chiragra*, is characterized, among other features, by the presence of enormously swollen and convex ridges on the median part of the telson; this species again shows considerable variation chiefly in regard to the spinules on the telson, ranging from forms that are profusely spinulate to forms that are quite smooth. Another

important variation noticed in this species is the presence or absence of setæ on the inner margin of the endopod of the uropod, but, unlike the spinules, these setæ are either absent (*forma typica*) or present (vars. *spinosus* and *espinosus*), there being no intermediate forms in which the setæ are reduced either in number or in size. Two varieties of *G. demani* Henderson, *spinosus* Bigelow and *espinosus* Borradaile have been recognized, but the latter is very imperfectly known. Partly removed from *chiragra* and its two closest allies, referred to above, are the two 5-keeled species, *G. glabrous* Brooks and *G. graphurus* Miers. As mentioned above, specimens of *G. chiragra* and *G. demani* have been recorded that show a transition from the 3-keeled to the 5-keeled stage. *G. graphurus* can be easily distinguished, among other characters, by the presence of fine transverse and longitudinal grooves on the first five abdominal somites. I have not taken into account in this synopsis de Man's *G. acutirostris*, as comparatively little is known of this species ; Kemp has suggested that the species may have been based on an abnormal specimen of *G. chiragra*. I have given here in brief my views on the relationships of the different members comprising the *chiragra* group of *Gonodactylus* ; these are practically the same as so ably and fully discussed by Kemp in 1913. Bigelow (1931) has also gone into this question in some detail and is in substantial agreement with Kemp on most of the important points.

Descriptive Notes.—Following the suggestion of Tattersall (1921), Kemp and I suggested in 1921 that Bigelow's (1893) *Gonodactylus spinosus* can probably be distinguished from *G. demani* by the presence in the former and absence in the latter of a fringe of setæ on the inner border of the endopod of the uropod. As it was not known whether Bigelow's type-specimen has these setæ or not, we suggested that, pending a re-examination of the type, Bigelow's form may be designated var. *spinosus?* of Henderson's *G. demani*. This doubt has since been removed by Bigelow's redescribing the type and showing that a fringe of setæ is present on the inner margin of the endopod. The type-specimen is further characterized by having small dorsal processes of the ophthalmic somite and by the telson being thickly covered with spinules and being as long as broad. Further, the intermediate and lateral marginal teeth of the telson are greatly reduced. I have examined several specimens of this variety from the Indian Museum collection and have found some variation in the amount of spinulation and in the relative size and distinctness of the marginal teeth of the telson. In Bigelow's figure of the type the lateral teeth are shown as practically absent and the intermediates as greatly reduced. In some of the specimens I have examined the condition is very much like this, though the lateral teeth are always a little more distinct than shown by Bigelow. The intermediate teeth also are sometimes better developed, and in some examples are large and separated from the submedians by large, deep notches. The spinulation on the telson, in all the Museum specimens that I have seen, is profuse to moderate and only very rarely somewhat scanty.

The three specimens in the John Murray Expedition collection are more or less typical. The telson is profusely spinulate and is almost as long as broad. The intermediate marginal teeth are well developed, and are separated from the submedians by deep incisions. The lateral marginals are considerably reduced, but are fairly distinct. The inner margins of the submedian teeth are finely serrate, and the tips of the teeth are provided with small articulating spines. The inner margin of the endopod is furnished with long hairs, which, as mentioned by Bigelow, are pinnate, like those on the outer border. There are 10–11

movable spines on the outer margin of the proximal segment of the exopod.* The carinæ of the sixth abdominal somite are also swollen and end in spines. The dorsal processes of the ophthalmic somite are small.

In the largest specimen, a female from Station 37, there is an indistinct transverse patch of colour on the posterior third of the carapace, and a broad transverse band on the sixth thoracic and first abdominal somites. There are indistinct diffused bands on some of the other abdominal somites also. In the male 18 mm. long there is a large number of small dark, almost black, chromatophores on various parts of the body. Some of these are aggregated on the posterior part of the carapace and some on the sixth thoracic and first abdominal somites. There are a few of these spots on some of the other abdominal somites also. On the telson there are two spots just under the tips of the submedian carinæ of the sixth abdominal somite, and another two indistinct ones under the tips of the intermediate carinæ also. In the third specimen the patch on the carapace is not seen, but those on the sixth thoracic and the first abdominal somites are quite distinct, as are also the four small spots near the anterior margin of the telson.

G. demani var. *spinosus* does not grow to a large size, the largest specimen so far recorded is under 40 mm. long. The *forma typica* also does not attain a large size, the largest example recorded by Kemp and Chopra from the Gulf of Suez was a little over 40 mm., and some females under 30 mm. in length, collected by Kemp in the Gulf of Manaar, were found to be guarding their eggs.

Distribution.—The variety has an extensive range of distribution over the Indo-Pacific region. Bigelow has described its range as extending "from Mauritius on the south to the Gulf of Suez, the Red Sea, and Persian Gulf on the north, and from Zanzibar and Ibo Archipelago, Portugese East Africa, in the west to the Sea of Java in the east". *G. demani* (*forma typica*) has also a somewhat similar range, though it has also been recorded further east than the variety. As remarked by Kemp and Chopra, the *forma typica* and the variety are both met with in the Red Sea, the Persian Gulf and the Gulf of Manaar.

The variety *spinosus*, like the typical *G. demani*, is not known to live in deep waters, most of the specimens so far recorded having been collected in the littoral at depths of a few fathoms only. The present examples also are not from any depth greater than 16 fathoms. The bottom at the place of capture consisted of sand, or of sand mixed with shells and corals.

Gonodactylus demani Henderson var. **? espinosus** Borradaile.

Gonodactylus espinosus Borradaile, 1898, pp. 35, 36, pl. v, figs. 5, 5*a*, 5*b*.
Gonodactylus demani var. *espinosus* Kemp, 1913, pp. 166, 167.

Occurrence.—Station 45, South Arabian coast, 38 metres. 5 ♂♂, 9 ♀♀, *ca.* 13–22 mm.
Station B [? M.B. I(*b*)], Red Sea, 29 metres. 1 ♀, *ca.* 11 mm.

Descriptive Notes.—In the matter of spinulation on the dorsal surface of the telson, *G. demani* is so variable that Kemp (1913, p. 153) suggested that should a wholly smooth example of this species be ever found it would only appear as the last link of a chain of continuous variation. Borradaile's *G. espinosus*, which Kemp regards as a variety of Henderson's species, appears to be such a form. The variety is based on a single male

* Dollfus (1938) has mentioned 12 or 13 movable spines in one of his specimens.

specimen, about 18 mm. long, obtained from Rotuma Island, on the north of Fiji, in the Southern Pacific. It resembles very closely *G. demani*, or rather its variety *spinosus* Bigelow, except in so far that there are no spinules on the telson. The telson is broader than long in Borradaile's variety, as also in the *forma typica*, but in Bigelow's variety *spinosus* the length and breadth of telson are almost equal. The inner border of the endopod of the uropod is fringed with setæ, thus differing in this respect from the typical form, but agreeing with var. *spinosus*.

There are, in the present collection, 15 small specimens of a *Gonodactylus* that I refer with considerable hesitation to Borradaile's *espinosus*. They vary in size from about 11 mm. to about 22 mm. from the tip of the rostrum to the tip of the submedian teeth of the telson, and both the sexes are represented in the collection. In all of them the telson is quite smooth ; the three ridges on the dorsal surface of the telson are greatly swollen and the middle one is very convex ; the telson is distinctly broader than long ; the intermediate marginal teeth are greatly reduced ; and the lateral marginals are obsolete, or even almost absent. The dorsal processes of the ophthalmic somite are small and the inner margin of the endopod of the uropod has setæ in all the examples. The specimens in a general way appear to belong to the *demani* section of the *chiragra* group, and, except for one or two differences, chiefly in the proportion of the telson, represent a non-spinulate phase of *G. demani* var. *spinosus*.

The characters enumerated above apply to all the specimens in a general way only, considerable variations in some of them being seen when they are examined in detail. In at least three examples, a male and two females, the condition is exactly as seen in Borradaile's figure ; the dorsal carinæ of the telson are enormously swollen and convex, and are separated from one another and from the rounded carinæ on the marginal teeth by narrow V-shaped spaces, the intermediate marginal teeth are considerably reduced and the laterals are altogether obsolete, the telson is distinctly broader than long and the carinæ on the sixth abdominal somite also are as seen in the figure of the type. There are, of course, no spinules on the telson. There seems little doubt that these three examples at least are referable to Borradaile's variety. There are other specimens, however, in which the dorsal carinæ are a little less swollen, the submedians a little less convex, the spaces between them and between the rather less rounded carinæ on the marginal teeth a little wider, and the intermediate marginal teeth a little more distinct. In two or three extreme cases the spaces between the carinæ are fairly wide, the submedian carinæ and the carinæ on the marginal teeth are rather sharp, and the intermediate marginal teeth are fairly well formed. In these specimens, all rather small, the telson is like that of *G. chiragra*. Another point worth mentioning is that though the lateral marginal teeth of the telson in all the specimens are obsolete or missing, more or less as in Borradaile's figure, in no example are the indentations of telson margin quite as reduced as shown in the figure. It is thus seen that there are some specimens in the present collection which resemble almost exactly Borradaile's *espinosus*, while there are others in which the telson comes quite close to that of *G. chiragra* ; between these two extremes the variation in the matter of the shape of the carinæ and their interspaces is almost continuous. It is, however, noteworthy that it is in small specimens only that the *chiragra* condition is well marked.

Another variable character seen in my specimens is the comparative development of the fluke-like prolongations at the posterior end of the median carina on the dorsal surface

of the telson. Borradaile's figure shows that this carina is uniformly swollen and rounded, and that there are no flukes at the posterior end. There are some specimens in my collection in which this condition prevails, but there are others in which the median carina is narrowed distally, and the posterior end has two fluke-like projections, sometimes small and insignificant, but in one or two cases large and well developed, as in *G. chiragra*.

In two specimens in the collection there is a faint and shallow longitudinal groove on each of the swollen submedian carinæ of the telson, imperfectly dividing it into two parallel keels. Hansen (1926, p. 28) described such longitudinal " impressions " in some of his specimens of *G. demani*, and suggested that this constituted " to some degree a transition towards *G. glabrous* Brooks, though it must be emphasized that the surface of the telson in *G. glabrous* with its five dorsal carinæ shows always an aspect of its own ".

In most of the specimens in the John Murray Expedition collection there are 9 movable spines on the outer margin of the proximal segment of the exopod of the uropod ; in one example there are 9 on one side and 10 on the other and in another there are 10 on each side.

The identification of the present specimens has been a matter of considerable difficulty. Two or three specimens with enormously rounded and convex keels, separated by narrow, V-shaped spaces, and possessing the other characters referred to above, appear to be clearly referable to Borradaile's *espinosus*. On the other hand, there are two or three examples which suggest the possibility of their being young individuals of *G. chiragra*. Between these two extremes there are intermediate forms. In all the specimens, however, the median keel of the telson is considerably swollen, more or less as in the *demani* section of the *chiragra* group, the smooth telson is broader than long, the marginal teeth of the telson, excepting the submedians, are considerably reduced, the spaces between the various carinæ, though variable in extent, are never really broad, and the dorsal processes of the ophthalmic somite are small. The combination of these characters has led me to refer the specimens to the variety *espinosus* of Borradaile. Like all other members of the *chiragra* group, this variety also is no doubt extremely variable in a number of characters.

All the specimens in my collection are small and probably immature, but it is noteworthy that the *chiragra* characters, referred to above, are most apparent in very small individuals only and tend to vanish or are at least toned down in larger examples. It seems likely that very young specimens present a somewhat generalized type of the group, becoming more and more differentiated with subsequent growth and assuming the full characters of the species or variety at or near maturity. Discussing the variations in the *chiragra* group, Kemp (1913, p. 151) was inclined to the view that distinctions between the varietal and typical forms are more pronounced in the young than in adults, or that small specimens greatly differing from one another and appearing to represent distinct varieties, etc., lose their peculiar features at subsequent moults and approximate to the typical form when they grow up. The small collection that I have studied does not support this view. Bigelow (1931, p. 111) has also discussed this point and is unable to agree with Kemp's hypothesis.

Several of the specimens have no colour at all, but in some there are distinct spots of a blackish colour on different parts of the body. In the posterior third of the carapace there are two to four small spots, and on the sixth thoracic and first and fourth abdominal somites there are two or three similar spots, which on the first abdominal are sometimes fused into a patch. On the sixth abdominal segment there is generally a small patch on

each side near the junction of the uropod and the basal part of the uropod is also pigmented. There is, in some cases, a general diffusion of minute chromatophores, which are especially aggregated on the margin of some of the thoracic and abdominal somites. Most of the colour markings are rather faint. Borradaile described the colour of the type-specimen as " a uniform dark olive-green ".

Distribution.—The variety was originally described from Rotuma Island, north-east of Fiji, in the Southern Pacific, " far distant from the region in which typical *G. demani* or var. *spinosus* have been found " (Kemp, 1913, p. 167). The present specimens are from the South Arabian coast and the Red Sea—localities in which both the *forma typica* and Bigelow's *spinosus* are also known to live. Borradaile's variety has thus been recorded from the two extreme ends of the Indo-Pacific region, but will probably be found in other localities also in this area. The variety lives in comparatively shallow waters only ; no details of depth have been recorded for the type, but the present examples are from depths under 40 metres. One specimen from Station 45 (South Arabian coast) was pulled off calcareous sponges or removed from the *débris* in the jar containing these. The sea-bottom at this station consisted of lithothamnion, while at the Red Sea station it was of sand, shell and coral.

Gonodactylus chiragra (Fabricius), *sensu lato*.

Gonodactylus chiragra, Kemp 1913 ; Bigelow, 1931.

Occurrence.—? Station 33, Gulf of Aden, 1295 metres. 1 ♀, *ca.* 12 mm.

Descriptive Notes.—In the tube containing telsons and other fragments of *Squilla investigatoris* Lloyd (see *supra*, p. 157) there is a small specimen of a *Gonodactylus* that belongs to the *chiragra* section of this genus. It is too small for satisfactory identification, but possibly belongs to *G. chiragra s.s.* The telson shows most of the characters of *G. chiragra*, but, as stated above, very young individuals in the *chiragra* group appear to have a generalized form, and probably assume the peculiar features of their species and varieties only when they grow up. The median keel on the telson is rounded and swollen, and has small fluke-like projections at the posterior end. The submedian keels are rather sharp and are separated from the median keel and from the somewhat sharp keels on the marginal teeth of the telson by wide gaps. The telson is smooth and is distinctly broader than long. The intermediate marginal teeth are well developed, and the laterals are obsolete, even their marginal notches being hardly discernible. The inner margin of the endopod of the uropod is fringed with setæ. There are 10 movable spines on the outer margin of the basal segment of the exopod on each side.

The specimen shows a few minor differences from typical examples of *G. chiragra* that may be mentioned. The antero-lateral angles of the rostrum are more broadly rounded than is usually the case. The carapace is almost as long as its greatest breadth, is very little narrowed in front, and its broadly rounded antero-lateral angles extend only very slightly beyond the rostral base. The bifurcate process of the uropod is also slightly different. The emargination between the two spines is deeper than is generally the case, and the outer spine, which is distinctly longer than the inner, extends a little beyond the distal margin of the last segment of the exopod.

Apart from its correct identification, the great importance of this specimen lies in the fact that it has presumably been dredged from the enormous depth of about 1300 metres.

All the records of *G. chiragra* and of other members of the *chiragra* group are from coral reefs and other similar situations in comparatively shallow waters only ; in fact I am not aware of any *Gonodactylus* known from depths exceeding 100 fathoms. If the present record, from a depth of about 700 fathoms, is correct, the bathymetric range of the genus is enormously increased. Apart from the great depth, the sea-bottom at Station 33 is stated to consist of green mud—a habitat hardly likely to be the home of a *Gonodactylus*. It is possible that the specimen was not really collected at this great depth, but got accidentally mixed with *Squilla* fragments from Station 33 at some later stage.

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[Only papers referred to in the present report are given in this list. For detailed bibliography see Kemp (1913) and Bigelow (1931). Komai (1927) and Dollfus (1938) have also given very useful lists of references. The bibliography recently (1938) given by Balss in his account of the Stomatopoda in Dr. H. G. Bronn's ' Klassen und Ordnungen des Tierreichs ' is a very comprehensive one, and in addition to systematics, contains also a large number of references to literature dealing with the morphology, development, etc., of the group.]

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CRUSTACEA: CARIDEA

BY

W. T. CALMAN, C.B., D.Sc., LL.D., F.R.S.

(Lately Keeper of Zoology)

WITH EIGHT TEXT-FIGURES

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In the collection of Caridea obtained by the Expedition 67 species have been identified, of which 7 are described as new, while 18 others are recorded for the first time from the area traversed by the "Mabahiss"; of these 18, 8 had already been reported from the Bay of Bengal or the Andaman Sea.

Of the total number 19 species were trawled or dredged in depths of less than 200 metres; the remainder were taken either on the bottom or in mid-water in deeper soundings. Further collecting in shallow water would doubtless have increased greatly the representation of certain groups characteristic of the littoral fauna, such as the Alpheidæ and Pontoniinæ; the richness of the Pontoniine fauna in these seas is emphasized by the fact that three out of the five species obtained by the Expedition appear to be new.

I am greatly indebted to Dr. Stanley Kemp, F.R.S., not only for having spared me a great deal of drudgery by his preliminary sorting of the collection, but especially for allowing me to consult his manuscript notes on several families of Caridea from the vast collections obtained by the "Discovery" investigations. Pending the completion of his report on these collections there is little point in discussing at length the geographical distribution of the species collected by the "Mabahiss". Such questions as the relation of the Arabian Sea fauna to that of the Atlantic must be left until we are in possession of the abundant data on the latter to be provided by the "Discovery" material.

A binomial nomenclature has been used for all the forms discussed in this report, including some to which trinomial designations had been applied by Dr. de Man. Subspecific names imply a degree of knowledge regarding variability and distribution which is not available for any of the forms with which I have to deal, and it is undesirable to employ them merely to record indecision.

LIST OF SPECIES.

(Species indicated by an asterisk have not previously been recorded from the area traversed by the expedition.)

Family Pasiphæidæ.

Pasiphœa sivado (Risso).
,, *unispinosa*, Wood-Mason.
Parapasiphaë Gilesii, Wood-Mason.
Psathyrocaris fragilis, Wood-Mason.
,, *infirma*, Alcock and Anderson.
Leptochela robusta, Stimpson.

Family Stylodactylidæ.
Stylodactylus bimaxillaris, Spence Bate.
Family Hoplophoridæ.
Hoplophorus typus, H. Milne Edwards.
**Systellaspis debilis* (A. Milne Edwards).
* ,, *affinis*, Faxon.
Acanthephrya eximia, S. I. Smith.
* ,, *Faxoni*, sp. n.
,, *purpurea*, A. Milne Edwards.
,, *sanguinea*, Wood-Mason.
,, *fimbriata*, Alcock and Anderson.
,, *curtirostris*, Wood-Mason.
,, *cucullata*, Faxon.
* ,, *indica*, Balss.
Hymenodora gracilis, S. I. Smith.
Family Nematocarcinidæ.
Nematocarcinus cursor, A. Milne Edwards.
,, *gracilis*, Spence Bate.
Family Thalassocaridæ.
Thalassocaris lucida (Dana).
Family Pandalidæ.
Plesionika martia (A. Milne Edwards).
,, *Alcocki* (Anderson).
* ,, *brevirostris*, Spence Bate.
* ,, *indica*, de Man.
* ,, *sindoi*, Rathbun.
,, *bifurca*, Alcock and Anderson.
* ,, *minor*, sp. n.
Parapandalus Zurstrasseni, Balss.
,, *Adensameri*, Balss.
,, *spinipes* (Spence Bate).
* ,, *filipes*, sp. n.
**Dorodotes reflexus*, Spence Bate.
Heterocarpus Wood-Masoni, Alcock.
,, *longirostris*, MacGilchrist.
,, *tricarinatus*, Alcock and Anderson.
* ,, *Sibogæ*, de Man.
,, *dorsalis*, Spence Bate.
Heterocarpoides levicarina (Spence Bate).
**Chlorotocus crassicornis* (Costa).
Family Alpheidæ.
Synalpheus Gravieri, Coutière.
,, *fossor* (Paulson).
* ,, *trispinosus*, de Man.
Alpheus spongiarum, Coutière.
* ,, *macrosceles*, Alcock and Anderson.
,, *euchirus*, Dana.

Family Hippolytidæ.

Merhippolyte Calmani, Kemp and Sewell.
**Ligur Edwardsi*, Sarato.

Family Palæmonidæ (sub-family Pontoniinæ).

Palæmonella vestigialis, Kemp.
**Periclimenes* (*Periclimenæus*) *arabicus*, sp. n.
* ,, (*Ancylocaris*) *crassipes*, sp. n.
**Pontonides unciger*, sp. n.
Pontonia anachoreta, Kemp.

Family Glyphocrangonidæ.

Glyphocrangon Smithii, Wood-Mason.
,, *Investigatoris*, Wood-Mason.
* ,, *assimilis*, de Man.
* ,, *Mabahissæ*, sp. n.
,, *prionotata*, Wood-Mason.

Family Crangonidæ.

Pontophilus indicus, de Man.
* ,, *incisus*, Kemp.
* ,, *angustirostris*, de Man.
* ,, *modestus*, de Man.
Ægeon bengalense (Wood-Mason).
* ,, *Rathbuni*, de Man.
,, *cataphractus* (Olivi).
* ,, *Lacazei* (Gourret).

Pasiphæa sivado (Risso).

Alcock, 1901, p. 59 (with refs.); Kemp, 1910, p. 37, pl. iv, fig. 12; Balss, 1914, p. 20; Balss, 1915, p. 17; Stephensen, 1923, p. 31; Balss, 1925, p. 237.

Occurrence.

Red Sea :

St. 5, 2 m. net, 500–0 m. (sounding 938 m.), 4 sp.

Gulf of Oman :

St. 76, 1 m. net, 600 and 1500 m. (sounding 3289 m.), 17 sp.

Northern area of Arabian Sea :

St. 61, 1 m. net, 1500–0 m., 4 sp.; 2 m. net, 2000–0 m., 3 sp. (sounding 2160–2290 m.).

Distribution.—Eastern Atlantic and Mediterranean (for details see Stephensen), Red Sea, East Africa, Bay of Bengal, Andaman Sea, Japan, 2000–0 m.

Remarks.—The specimens from the Gulf of Oman and the northern area of the Arabian Sea differ from British specimens of *P. sivado* in the following points :

(1) Ovigerous specimens are only from 30 to 36 mm. in total length. Stephensen found the minimum length of ovigerous specimens from the Atlantic and Mediterranean to be 48 mm.

(2) The " branchiostegal sinus " on the antero-inferior margin of the carapace below the branchiostegal spine is a deep, nearly right-angled notch. In British specimens it is a very shallow concavity.

(3) The palm of the first and second chelipeds has a row of 4 to 6 spines on its posterior edge, and the carpus has 1 or 2. No spines are present in any European specimens I have examined.

(4) The first maxilliped is markedly wider. It is difficult to get accurate measurements, but the basal lamina is only about one-half longer than wide and the distal segment is hardly narrowed at the base, where its width is more than half its length. In British specimens the basal part is twice as long as wide and the distal segment is contracted at the base to one-quarter of its length.

(5) There is no trace of a pleurobranch on the last thoracic somite. As I indicated in 1903 (p. 419) this gill only appears late in development, and Kemp (1910, p. 37) found no trace of it in specimens 30 mm. in length. I now find that in British specimens of 36 mm. it is represented by a simple finger-shaped papilla. At about 40 mm. it has become flattened, lanceolate, and shows traces of transverse ridges. In a specimen of 53 mm., the smallest ovigerous specimen I have seen, it is still in much the same condition, and not until a length of about 65 mm. is reached have the ridges developed into gill-lamellæ, to the number of about 9 (Kemp says 5 or 6) obscurely divided into an anterior and posterior series. Claus's figure (1885, pl. iv, fig. 36), presumably from a Mediterranean specimen, shows a well-formed gill with about 25 lamellæ, but in his text he refers to it as " eine rudimentäre Lamella ".

In addition there are various small differences in the proportions of the limbs (for example, the merus of the posterior legs is a little longer in the Arabian specimens), but they are too small to be significant unless verified on a large number of specimens. The spines on the merus of the first and second chelipeds (13–15 and 18+) are more numerous than in the British specimens I have examined, but Stephensen has shown (1923, p. 34) that the numbers of these spines are significantly higher in Mediterranean than in Atlantic specimens of *P. sivado.*

The characters enumerated above might have justified the separation of these specimens under a new specific name were it not that the Red Sea specimens, while agreeing with the others in characters 1, 2, 3 and 5, differ markedly from them in respect of character 4, the first maxilliped being of the narrow type found in Atlantic specimens of *P. sivado.* For the present, therefore, until some more sharp-sighted investigator can discover further characters to distinguish them, all these forms may be left under the name *P. sivado.* Just as Stephensen has shown that Mediterranean specimens differ, on the average, from Atlantic specimens of that species, it seems likely that more strongly marked races inhabit the Red Sea and the Arabian Sea. The limits of these races and of their habitats will have to be verified on much larger collections before it is worth while to distinguish them by names.

Balss comments that his Red Sea specimens were uniformly about 35 mm. in total length, and ours agree with this. Those from the Gulf of Oman are, on the whole, even smaller (ovigerous at 30 mm.). Wood-Mason's male specimens from the Andamans were 48 mm. in length and Alcock's ovigerous female measured the same. Balss's Japanese specimen (ovigerous) reached 70 mm.

Pasiphœa unispinosa, Wood-Mason.

Pasiphaë unispinosa, Wood-Mason, 1893, p. 163 ; Illustr. " Investigator ", 1892, pl. iii, fig. 7 ; (*Pasiphœa*) Alcock, 1901, p. 60.

Occurrence.

Gulf of Aden :

St. 25, trawl, 620 m. 1 ♀.

Distribution.—Arabian Sea, Bay of Bengal, Andaman Sea, 365–1133 m.

Remarks.—The specimen is damaged, but, except for its small size (total length 35 mm.), it shows all the characters mentioned as distinguishing this species.

Parapasiphaë Gilesii, Wood-Mason.

Wood-Mason, 1893, p. 166 ; Illustr. " Investigator ", 1892, pl. iii, fig. 8 ; (*Parapasiphæa*) Alcock, 1901, p. 66.

Occurrence.

Northern area of Arabian Sea :

St. 61, 1 m. net, 1000–0 m., 3 young.

1 m. net, 1500–0 m., 1 sp., 1 young.

2 m. net, 2000–0 m., 2 sp., 1 young (sounding 2160–2290 m.).

St. 62, trawl, 1893 m., 2 sp.

Gulf of Oman :

St. 76, 2 m. net, 2500 m. (sounding 3829 m.), 2 sp.

Central part of Arabian Sea :

St. 95, 2 m. net, 430–984 m. (sounding 4277 m.), 1 young.

Distribution.—Andamans, N. of Laccadives, 1188–1271 m. (W. of Cape Verde Is., 370–0 m., Kemp, MS.).

Remarks.—The largest of the specimens (48 mm. total length) is much smaller than the largest recorded by Alcock, and is an immature female. In the smaller specimens the rostrum is shorter than the eyes.

In the smallest specimens (under 25 mm. total length) noted above as young, the dorsal crest has a prominent rounded tubercle (suggesting the remains of a larval spine) about one-third of the length of the carapace from the front, and only two to three serrations are visible behind it.

Psathyrocaris fragilis, Wood-Mason.

Wood-Mason, 1893, p. 171, pls. x and xi ; Illustr. " Investigator ", 1901, pl. lii, fig. 5 ; Alcock, 1901, p. 69 ; de Man, 1920, p. 17.

Occurrence.

Maldive area :

St. 158, trawl, 786–1170 m. 1 ♀.

Distribution.—Arabian Sea, Bay of Bengal, Malay Archipelago, 313–1882 m., Bay of Biscay (var. *atlantica*), 797 m.

Remarks.—The single specimen lacks both pairs of chelipeds, but agrees closely with the descriptions except that the surface of the carapace behind and below is coarsely and irregularly rugose.

Psathyrocaris infirma, Alcock and Anderson.

Alcock and Anderson, 1894, p. 159 ; Illustr. " Investigator ", 1895, pl. xii, fig. 7 ; Alcock, 1901, p. 71 ; Balss, 1925, p. 236, text-fig. 9.

Occurrence.

Gulf of Aden :

St. 18, 2 m. net, 900–0 m. (sounding 1375 m.), 1 sp.

St. 193, trawl, 1061–1080 m., 10 sp.

Distribution.—E. Africa, Indian Ocean, Andaman Sea, 740–1289 m.

Remarks.—The specimens are all much damaged, not having a single complete cheliped among them, but the agreement with the accounts of this species is complete in all visible characters.

Leptochela robusta, Stimpson.

Kemp, 1925, p. 252 (with refs.).

Occurrence.

Red Sea :

St. M.B. I, dredge, 26 m., 1 sp.

Gulf of Oman :

St. 71, trawl, 106 m., 10 sp.

Maldive area :

St. 139, grab, 57 m., 2 sp.

Distribution.—Red Sea, Maldives, Nicobars, Andamans, Burma, Malay area, N.E. Australia, China, Hawaii.

Remarks.—Two of the females from St. 71 have the carapace tricarinate, and one of these is ovigerous. As Kemp has pointed out, this character seems to be found only in breeding females. Balss (1925, p. 235) states that the species of *Leptochela* belong to the surface plankton, but the general facies is not that of planktonic animals. The last two pairs of legs are stout, flattened, fringed with stiff setæ and carried in an attitude recalling that of the posterior legs of Cumacea, suggesting that they are used for digging in sand.

Stylodactylus bimaxillaris, Spence Bate.

Kemp, 1925, p. 257 (with refs.) ; Calman, 1925, p. 16 ; Balss, 1925, p. 239.

Occurrence.

Gulf of Aden :

St. 194, trawl, 220 m., 1 ♀ ovig.

Zanzibar area :

St. 105B, trawl, 238–293 m., 1 ♀ ovig.

Distribution.—E. Africa, Cape, Japan, Admiralty Is., 150–1380 m.

Remarks.—The specimen from the Gulf of Aden has a tuft of long soft hairs on the eyestalks and others on the limbs and dorsal crest, as in Balss's Japanese specimen, while in the one from Zanzibar, as in Balss's " Valdivia " specimen from the same locality, the long hairs are, for the most part, absent.

Hoplophorus typus, H. Milne-Edwards.

H. typus, H. M. E., Balss, 1925, p. 248, text-figs. 21–23 (with synonmy).
Oplophorus typus, H. M. E., and *O. gracilirostris*, A. M.-E., Chace, 1936, p. 30.

Occurrence.

Gulf of Aden :

St. 16, trawl, 186 m., 11 young.

St. 180, grab, 397 m., 1 young.

St. 186, 2 m. net, 952–0 m. (sounding ?), 1 young.

St. 188, trawl, 528 m., 1 young.

Central part of Arabian Sea :

St. 95, 2 m. net, 430–984 m. (sounding 4277 m.), 1 ♀ ovig., 1 ♂, 1 young.

Zanzibar area :

St. 115, trawl, 640–658 m., 1 ♂.

St. 118, trawl, 1789 m., 1 young.

Maldive area :

St. 140, dredge, 515–525 m., 3 ♀ ovig., 1 ♂.

Distribution.—West Indies, Arabian Sea, Andaman Sea, Malay Archipelago, Philippines, New Guinea, Fiji, Hawaii, 200–2600 m.

Remarks.—In addition to the specimens enumerated above I have examined the two referred by Bate to *H. typus* and the holotypes of *H. brevirostris*, Bate, and *H. longirostris*, Bate, in the " Challenger " collection. As a result I am in agreement with Balss, who unites all these, together with *H. gracilirostris*, A. M.-E., in a single species. Chace dissents from this, distinguishing *H. gracilirostris* from *H. typus* by the admedian carinæ at the base of the rostrum which are sub-parallel instead of converging posteriorly, by the shorter unarmed portion of the antennal scale, the shorter rostrum, and the presence of a tooth on the first abdominal pleuron. The specimens now examined show uncorrelated variation in all these characters, affording no possibility of recognizing more than one species.

In the series of 11 young specimens from St. 16, the length of the carapace ranges from 5·25 to 8·5 mm. The rostrum is twice the length of the carapace in the smallest, $1\frac{1}{4}$ in the largest specimen. Only in the larger specimens is there an obscure indication of a tooth on the lower edge of the carapace. In all there is an indication of notching on the front edge of the first abdominal pleura, but the lower corner of the notch is not at all produced. In the smallest individuals the dorsal spine of the third abdominal somite extends beyond the spine of the fifth. In the largest it only reaches the middle of the fifth somite.

These specimens and others of like size show a considerable resemblance to Coutière's *H. Grimaldii*, from which they differ chiefly in having the setose part of the inner edge of the antennal scale defined distally by a shallow notch, not by a recurved tooth.

Systellaspis debilis (A. Milne Edwards).

Balss, 1925, p. 242 (with synonymy) ; Chace, 1936, p. 29.
Acanthephyra debilis, Calman, 1925, p. 13.

Occurrence.

Zanzibar area :

St. 115, trawl, 640–658 m., 1 ♀ ovig.

St. 121, trawl (sounding 925 m., net apparently not on bottom), 1 ♀ ovig.

Distribution.—North and South Atlantic, South Indian Ocean, Malay Archipelago,

Hawaii. The exact depth at which this species lives is not indicated by many of the records, but the " Michael Sars " took it at 50 m. and down to over 1500 m.

Remarks.—After Balss's exposition I must withdraw the doubt I expressed (*l. c.*) on the validity of the genus *Systellaspis*.

The specimens in the present collection agree minutely with specimens from the West of Ireland and from the Cape, with which I have compared them. They greatly extend the known range of this widely distributed species.

Systellaspis affinis (Faxon).

Acanthephyra affinis, Faxon, 1896, p. 162, pl. ii, figs. 1–3 ; Kemp, 1906, p. 21.
Systellaspis affinis, de Man, 1920, p. 43 ; Chace, 1936, p. 29.

Occurrence.

Zanzibar area :

St. 107, trawl, 421–457 m., 45 sp., ♂ and ♀, many ovig.

Distribution.—Off Grenada, West Indies, 289 m., China Sea (Kemp MS.).

Remarks.—Faxon distinguished this species from *S. lanceocaudata*, Bate, by the following characters : " The apical tooth of the antennal scale projects forward far beyond the membranous part of the organ ; the telson is shorter than even the inner branches of the posterior pair of abdominal appendages, and its dorsal surface is flattened but not grooved."

As regards the shape of the antennal scale, Spence Bate's statement (1888, p. 759) that in *S. lanceocaudata* " the squamous portion exists as a rounded extremity beyond the apical tooth " is in error. In the holotype the apex of the scale does not differ from Faxon's figure (1896, pl. ii, fig. 3).

The specimens in the present collection agree with Faxon's account and differ from the holotype of *S. lanceocaudata* in having the telson shorter than the endopods of the uropods and slightly flattened, not grooved, dorsally. A comparison with Faxon's figure shows no noteworthy differences except that there is in our specimens a distinct dorsal denticle and a minute lateral denticle above the articulation on the fourth abdominal somite, and that the carpus of the chelipeds is distinctly shorter than the palm. The pleuron of the fifth somite has a blunt tooth in the middle of the hind margin which is barely indicated in Faxon's figure.

Compared with the holotype of *S. lanceocaudata* our specimens have the dorsal surface of the sixth abdominal somite rounded instead of grooved, and that of the fifth somite is rounded, not keeled. The pleura of the fifth somite are less produced, less than one-third the length of the sixth somite instead of nearly one-half, as in *S. lanceocaudata*. The antennal scales of Bate's specimen have the outer edge distinctly convex, while in our specimens it is nearly straight.

Dr. S. W. Kemp kindly allows me to quote the following notes on the photophores of these specimens. After three or four more years preservation in spirit the organs are much less easily seen than they were when these notes were made.

" Luminous organs much as in *S. debilis*. Others would no doubt be seen in fresh material ; those noted are the following :

" Eyestalk : A linear streak on outer side, sometimes divided into two, ending distally on a narrow portion of the stalk that protrudes far into the cornea (much more so than in *S. debilis*). A spot on lower side situated on outer face of ventral papilla.

" 1st maxilliped : None visible.

" 3rd and 4th legs : A spot at proximal end of carpus placed posteriorly (not anteriorly as in *S. debilis*).

" 5th leg : Spot on carpus and propodus with a similar spot proximally and a streak running almost throughout length ; all placed posteriorly. A transverse streak behind coxa, not extending so far upwards laterally as in *S. debilis*.

" Pleopods : One at distal end of each protopodite, placed antero-externally.

" Carapace : In a few specimens the row near the inferior border is visible. The organs correspond with the raised portions of the interrupted carina and comprise about 12 short streaks anteriorly and a long streak posteriorly.

" Abd. segments : One on each side of 1st seg., placed laterally about middle and not far from the anterior margin ; the organ is situated on a small protuberance and faces downwards.

" Diffuse pigment spots at articulation points of 4th/5th and 5th/6th somites may be luminous organs.

" 6th somite with a pair of spots at distal end.

" Telson : On upper side at base a small spot in middle and one on either side. These have no counterpart in *S. debilis*."

A coloured sketch of a living specimen made by Lt.-Col. Seymour Sewell during the voyage shows a deep red colour, densest on the anterior part of the carapace, and forming ill-defined transverse bands on the abdominal somites. The luminous organs cannot have been conspicuously coloured, for they are not indicated in the sketch.

Acanthephyra eximia, S. I. Smith.

S. I. Smith, 1884, p. 376 (*eximea* in error, correctly *eximia* on p. 377) ; *id.*, 1886, p. 63, pl. xiv, fig. 1 ; Balss, 1925, p. 258 (with synonymy) ; Chace (*eximea*), 1936, p. 27.

Occurrence.

Gulf of Aden :

St. 185, trawl, 2000 m., 1 ♂.

Northern area of Arabian Sea :

St. 81, trawl, 3351 m., 1 ♀.

Zanzibar area :

St. 124, trawl, 914 m., 1 ♂, 1 ♀ ovig.

Distribution.—North and South Atlantic, E. Africa to Japan and Hawaii, Natal, Kermadec Is., 365 to 3750 m.

Remarks.—I have no doubt that Chace is right in treating *A. brachytelsonis*, Bate, as a synonym rather than a variety of this species.

Acanthephyra Faxoni, sp. n. (Text-fig. 1.)

A. approxima, Faxon, 1895, p. 162, *nec* Spence Bate, 1888, p. 755, pl. cxxvi, fig. 8.

Occurrence.

Gulf of Aden :

St. 184, trawl, 1270 m., 1 ♂ (holotype), 1 ♀, 2 young.

Zanzibar area :

St. 108, trawl, 786 m., 2 ♀, 1 damaged.

St. 121, trawl (sounding 925 m., net apparently not on bottom), 1 ♀, 1 young.

Distribution.—Gulf of Panama, Galapagos Is., 701–2133 m.

Description.—Integument soft, but not quite membranous. Carapace with a sharp dorsal keel extending to the hind edge, branchial region defined above by a curved or angulated ridge, antennal (branchiostegal) spine prominent but not continued backwards by a ridge. Rostrum straight, or very gently curved, a little longer or shorter than the carapace, 10–11 teeth above, of which the proximal 6 to 9 are closely set, 3 or 4 being behind the orbit, and the distal teeth widely spaced along the rest of the dorsal edge ; 4 teeth below.

First abdominal somite smoothly rounded dorsally, the remaining somites sharply keeled, keel produced into a large decurved tooth on the third somite, very short teeth on the fourth and fifth, and a slightly larger tooth on the sixth.

Eyes small and somewhat flattened, little wider than the peduncle, pigment brown.

Text-fig. 1.—*Acanthephyra Faxoni*, sp. n. St. 184, ♂ Holotype.

Antennal scale three-quarters as long as carapace, greatest width one-quarter of length, narrowly truncated at tip, with projecting spine.

Posterior legs with spines on ischium and merus, but without fringes of setæ.

Telson shorter than endopod of uropods, with three pairs of very minute dorsal spines.

Total length about 74 mm.

Remarks.—The holotype of *A. approxima*, Spence Bate, has a distinct dorsal carina on the first abdominal somite. Spence Bate's description is ambiguous on this point, one passage (1888, p. 755) implying the absence, and another (p. 757) the presence of a carina. Kemp, who had examined the holotype, includes this carina among the characters of the species (1906, p. 23), and he is followed by Balss (1925, p. 251). Chace, however, includes the species among those which have " the first abdominal somite not dorsally carinate " (1936, p. 27). As he had not seen the holotype, he was relying on an examination of the specimens referred to this species by Faxon (1895, p. 162), who does not mention this character in his short description.

The holotype of *A. approxima* has the rostrum broken and the statement that it is

armed with more than two teeth below (which decides the place of the species in the keys of Kemp and Balss) depends on the identification of Faxon's specimens with Spence Bate's species.

A. approxima was described from a single specimen about 47 mm. in total length taken at the same station as the single specimen of *A. carinata*, Spence Bate, which is about 142 mm. long. No other species of the genus was taken at that station. Since the two specimens agree in the unusual character of having a crest on the first abdominal somite, it seems probable that they should be referred to the same species, the few palpable differences between them, such as the greater depth of the base of the rostrum in *A. carinata*, being associated with the very great difference in size.

By the kindness of Mr. Chace I have been allowed to examine one of Faxon's specimens from "Albatross" Station 3403. It is an ovigerous female and it agrees perfectly with the "John Murray" specimens except in the following points: The rostrum has $\frac{9}{5}$ teeth (Mr. Chace informs me that the range of variation is $\frac{6\text{–}9}{4\text{–}7}$), of which only two are behind the orbit, and the crowding of the posterior teeth is less marked than in our specimens. The antennal scale is distinctly narrower at the apex. The telson is equal to the endopod of the uropods, with 6–5 very minute dorsal spines.

Acanthephyra purpurea, A. Milne Edwards.

Kemp, 1906, p. 4, figs. (with synonymy); Kemp, 1913, p. 64; Balss, 1925, p. 252; Calman, 1925, p. 12.

Occurrence.

Zanzibar area:

St. 121, trawl (sounding 925 m., net apparently not on bottom), 3 ♀, 4 ♂, 3 young.

Distribution.—Atlantic (for details see Balss, *l. c.*, and Stephensen, 1923, p. 252), Southern Indian Ocean, Natal to Zanzibar and Seychelles, W. of Sumatra, Banda Sea, S. Japan, Kermadec Is., S. Australia, Gulf of Panama, 1200–2000 m., younger stages at less depths.

Remarks.—Kemp, and later Balss, have recorded this species from the Western Indian Ocean, but not much north of the Zanzibar area. Further north, as Kemp points out, it seems to be replaced by *A. sanguinea*. West of Sumatra, however, the "Valdivia" took both species at one station.

The largest complete specimen in this collection, a male, agrees with Kemp's Indian Ocean specimens in having the telson longer than the exopod of the uropods, but in other, smaller, specimens it is no longer than the endopod. In all the specimens the telson has four pairs of dorsal spinules (in one 4–5), and there are well-marked teeth on the fourth and fifth abdominal somites. The rostral armature is $\frac{8\text{–}9}{5\text{–}6}$. The eyes are black.

Acanthephyra sanguinea, Wood-Mason.

Wood-Mason, 1892, p. 358, text-fig. 1; Illustr. "Investigator", 1892, pl. iii, fig. 3; Alcock, 1901, p. 79; Kemp, 1906, p. 23; Balss, 1925, p. 256, text-fig. 25; Chace, 1936, p. 27.

Occurrence.

Gulf of Aden :

St. 18, 2 m. net, 900–0 m. (sounding 1375 m.), 1 young.

St. 185, trawl, 2000 m., 1 ♀.

Central part of Arabian Sea :

St. 95, 2 m. net, 430–984 m. (sounding 4277 m.), 2 ♂.

St. 96, 2 m. net, 400–645 m. (sounding 4459 m.), 1 ♂, 1 ♀, 7 young.

Distribution.—Arabian Sea, Bay of Bengal, Andaman Sea, 349–3200 m.

Remarks.—The large male from St. 96 has the whole carapace and much of the abdomen still covered with a close investment of fine scale-like setæ which have been more or less completely removed from all the other specimens. When the scales are removed the surface of the integument is seen to be covered with fine pits closely set in irregular curving rows. These pits are less conspicuous in specimens of *A. purpurea*.

Acanthephyra fimbriata [Wood-Mason, MS.], Alcock and Anderson.

Acanthephyra armata var. Wood-Mason, 1892, p. 359, fig. 2 ; Illustr. " Investigator ", 1892, pl. iii, fig. 1.
A. armata var. *fimbriata*, W.-M., Alcock and Anderson, 1894, p. 156.
A. armata, Alcock, 1901, p. 78 ; Balss, 1925, p. 256, fig. 26.
A. fimbriata, Chace, 1936, p. 27.
Nec *A. armata*, A. Milne Edwards, 1881, p. 12.

Occurrence.

Gulf of Aden :

St. 33, trawl, 1295 m., 1 young.

St. 34, trawl, 1022 m., 4 ♀, 1 young.

St. 193, trawl, 1061–1080 m., 2 ♀.

Distribution.—Off S. coast of Arabia (Lloyd), off S.W. India (Alcock), Bay of Bengal, Andaman Sea, 867–1234 m.

Remarks.—I follow Chace (1936, p. 27) in regarding *A. fimbriata* as a species distinct from *A. armata*, mainly because of the very marked ridge behind the antennal tooth and the dense fringes of long setæ on the posterior legs. The lower tooth of the rostrum, however, is well in front of the middle of its length and not far behind the tip of the antennal scale in the present specimens. Comparing our specimens with that of *A. armata* obtained by the " Challenger " the only further differences noted were that the telson does not exceed the endopod of the uropod in *fimbriata*, while it is equal to the exopod in *armata*. In the " Challenger " specimen the hinder edge of the third and less distinctly that of the fourth abdominal somite has a rounded notch on either side of the dorsal tooth. In our specimens this notch is absent and the tooth of the third somite is therefore shorter, not exceeding those on the following somites.

Acanthephyra curtirostris, Wood-Mason.

Balss, 1925, p. 261, fig. 30 (with references) ; Chace, 1936, p. 26.

Occurrence.

Maldive area :

St. 156, trawl (not on bottom, sounding 1317 m.), 1 ♂.

Distribution.—Arabian Sea, Bay of Bengal, Andaman Sea, Malay Archipelago, California, Panama, 665–4080 m.

Acanthephyra cucullata, Faxon.

Faxon, 1895, p. 167, pl. xliv, figs. 1–1*b* ; Balss, 1925, p. 262, fig. 31 ; Balss, 1927, p. 269, fig. 32 ; Chace, 1936, p. 26.

Occurrence.

Gulf of Aden :

St. 185, trawl, 2000 m., 1 ♂.

Maldive area :

St. 162, trawl, 1829–2051 m., 1 young ♀.

Distribution.—E. Africa, 0–2000 m., Gulf of Panama, 3239 m.

Remarks.—Both our specimens are much injured, but so far as can be seen they agree well with Faxon's account, except that the spiniform apex of the rostrum is longer, reaching a little beyond the eyes. The male measures about 60 mm. in total length.

Acanthephyra indica, Balss.

Balss, 1925, p. 264, text-figs. 34, 35 ; ? *Acanthephyra* sp., de Man, 1920, p. 68, pl. vi, fig. 16.

Occurrence.

Gulf of Oman :

St. 76B, 2 m. net, 2500 m. (sounding 3289 m.), 1 ♂.

Central part of Arabian Sea :

St. 95, 2 m. net, 430–984 m. (sounding 4277 m.), 1 ♀, 2 young.

Southern area of Arabian Sea :

St. 131D, 1 m. net, 1500–0 m. (sounding 4622 m.), 1 ♀ ovig.

Distribution.—Between Sumatra and Ceylon, 2500–0 m., Malay Archipelago, 2000–0 m.

Remarks.—The specimens, although a little smaller than that of Balss (carapace 8 mm., abdomen about 22 mm.) agree closely with his description and figures. Almost the only notable difference is that the telson is a trifle longer than the endopod of the uropods, although shorter than the exopod. The mandible figured by Balss is that of the right side. On the left there is no prominent tooth at the distal end of the incisor edge.

Hymenodora gracilis, S. I. Smith.

S. I. Smith, 1886, p. 76, pl. xii, fig. 6 ; Stephensen, 1923, p. 60.

Occurrence.

Northern area of Arabian Sea :

St. 61, 1 m. net, 1500–0 m. (sounding 2160 m.), 2 young.

Remarks.—I owe the identification of these specimens to Dr. Stanley Kemp, who will, in due course, publish his reasons for separating *H. gracilis* from *H. glacialis* (Buchholz) and will discuss the distribution of the two species.

Nematocarcinus cursor, A. Milne Edwards.

N. cursor, A. M. E., Alcock, 1901, p. 89 ; Balss, 1925, p. 272.
N. undulatipes, Spence Bate, de Man, 1920, p. 83, pl. viii, figs. 20–20*h*.

Occurrence.

Gulf of Aden :

St. 34, trawl, 1022 m., about 50 sp., many ovigerous.

St. 193, trawl, 1061–1080 m., 17 sp.

South Arabian Coast :

St. 54, trawl, 1046 m., about 50 sp., some ovigerous.

Zanzibar area :

St. 109, trawl, 640 m., 11 sp.

Maldive area :

St. 158, trawl, 786–1170 m., 3 sp.

Distribution.—West Indies and east coast of North America, from East African coast to Fiji, 209–2033 m.

Remarks.—The specimens enumerated above agree in general with Alcock's description of the species which he identifies with *N. cursor*, and for which de Man prefers the name *N. undulatipes*. The only noteworthy divergence from the accounts of these authors is that the number of rostral teeth ranges from 9 to 18 (3 sp.), 19 (1 sp.), or 20 (1 sp.), thus transgressing the limits which they set for the species *N. gracilis*. In none of these specimens, however, where the carpus of the first legs is present, does it extend by more than one-third of its length beyond the antennal scale.

Apart from the numbers of rostral teeth, the shape of the rostrum itself shows considerable differences, the most aberrant specimens being those from St. 158, which have the rostrum more slender, straighter, and more acute than any of those figured by de Man ; in these specimens also the number of rostral teeth (9–10) is less than in any others in the collection.

Nematocarcinus gracilis, Spence Bate.

Spence Bate, Alcock, 1901, p. 90 ; de Man, 1920, p. 90, pls. viii and ix, figs. 21–21*h*.

Occurrence.

Maldive area :

St. 158, trawl, 768–1170 m., 3 sp.

St. 159, trawl, 914–1463 m., 3 sp.

Distribution.—Laccadives to Hawaiian Is., 165–705 m.

Remarks.—The specimens enumerated above are provisionally referred to *N. gracilis* because one individual from each station shows the first legs extending beyond the scale by two-thirds of the carpus. None of the other legs is complete.

The upper rostral teeth are from 15 to 19 and are thus within the limits assigned to *N. gracilis* by de Man.

Thalassocaris lucida (Dana).

Kemp, 1925, p. 283 (with synonymy).

Occurrence.

Red Sea :

St. M.B. I(*b*), dredge, 26 m., 1 ♀.

Maldive area :

St. 143, trawl, 797 m., 1 ♀ ovig.

CORRIGENDUM.

Reports of John Murray Expedition, 1933-34, Vol. VI, No. 4, p. 197.

Plesionika martia (A. Milne Edwards).

By some mischance which cannot now be explained or excused, the records of this species from three stations were omitted from the published report, with the result that only fifteen specimens were indicated although the species was actually represented by a vastly larger number of specimens than any other in the collection (over 428 ; *Parapandalus spinipes* (Sp. Bate) was represented by 169). The following is a complete list of the localities where the species was obtained :

Gulf of Aden :

St. 25, trawl, 620 m., 1 young.
St. 176, trawl, 655–732 m., 1 ovig. ♀.

Zanzibar area :

St. 107, trawl, 421–567 m., 7 young.
St. 109, trawl, 640 m., 1 ♀, 6 young.
*St. 115, trawl, 640 m., 13 adults, including ovig. ♀♀.

Maldive area :

*St. 145, trawl, 494 m., 400 specimens, mostly adults, many ovig. ♀♀.
*St. 154, trawl, 457 m., (?) (probably a small sample).

Note.—The specimens from Stations 25 and 154 are not in the British Museum Collection nor in the register. Our notes show that St. 154 was represented, though no record was made of the number of specimens.

* Omitted

Distribution.—Maldives, Saya de Malha, Christmas Is., Loo Choo Is., Ladrones, Fiji.

Plesionika martia (A. Milne Edwards).

Plesionika martia var. *semilævis*, Spence Bate, de Man, 1920, p. 116, pl. x, figs. 24–24*b* (with synonymy).
P. martia, Balss, 1925, p. 278 ; Schmitt, 1926, p. 377.

Occurrence.

Gulf of Aden :

St. 25, trawl, 620 m., 1 young.

St. 176, trawl, 655–732 m., 1 ♀ ovig.

Zanzibar area :

St. 107, trawl, 421–567 m., 7 young.

St. 109, trawl, 640 m., 1 ♀, 6 young.

Distribution.—Eastern Atlantic from Ireland to the Mediterranean, Indo-Pacific from Zanzibar and the Cape to Hawaii, South and East Australia and the Kermadec Is., 165 to 2190 metres.

Remarks.—De Man distinguishes as *P. martia* var. *semilævis*, Spence Bate, a form in which the rostrum is shorter than in the type, and assigns to it the specimens obtained in the Malay Archipelago, Australia, Fiji and the Kermadec Is. The typical form is said to inhabit the European seas, East and South Africa, Bay of Bengal, Andaman Sea, Tasman Sea, Japan and Hawaii. Schmitt has shown, however, that Australian specimens belong to the typical form. Balss regards *P. semilævis*, Spence Bate, as a synonym of *P. martia* (A. M. E.), a view with which I agree.

Plesionika Alcocki (Anderson).

Pandalus Alcocki, Anderson, 1896, p. 92 ; *Pandalus* (*Plesionika*) *alcocki*, Illustr. " Investigator ", 1901, pl. lii, figs. 2 and 4 ; Alcock, 1901, p. 97 ; *Plesionika Alcocki*, Balss, 1925, p. 278.

Occurrence.

Maldive area :

St. 158, trawl, 786–1170 m., 1 ♂, 1 ♀ ovig.

Distribution.—Gulf of Aden, Arabian Sea, E. Africa, Bay of Bengal, Andaman Sea, 500–1125 m.

Remarks.—The specimens are larger than the female measured by Alcock (carapace length ♀ 22, ♂ 20·5 mm.). They agree closely with the descriptions except that in the female the dactylus of the third leg at any rate is not minute, but resembles that of the male.

Plesionika brevirostris, Spence Bate.

Spence Bate, 1888, p. 650, pl. cxiii, fig. 5.

Occurrence.

Maldive area :

St. 145e, trawl, 494 m., 1 ♀.

Distribution.—Between Philippine Is. and Borneo, 457 m.

Remarks.—The single specimen measures about 60 mm. in total length and its carapace 13 mm., being just half the size of the holotype. It has 5+4 rostral teeth above

(the type having 3+4), and the distal apical part of the rostrum is obscurely toothed above and below. These subapical teeth become obsolete as they approach the tip, but about $\frac{6}{7}$ can be counted. The type is described and figured as having both edges of the rostrum smooth towards the tip, but under the microscope obscure traces of teeth can be discerned on the lower edge, to the number of about 10.

A still more conspicuous difference from the type is provided by the eye, which, in the new specimen, is provided with a distinct "ocellus". Closer examination shows that this ocellus is simply a peninsula projecting from the corneal area and showing the same facetting of the surface. The type shows the same peninsula (as, indeed, do most other members of the genus), which only differs in the extent to which it is abstricted at the base.

Plesionika indica, de Man.

? *Pandalus longipes*, A. Milne-Edwards, 1881, p. 15; 1883, pl. xx.
Plesionika longipes var. *indica*, de Man, 1917, p. 279; 1920, p. 121, pls. x and xi, figs. 25–25*g*.

Occurrence.

Zanzibar area:

St. 105B, trawl, 238–293 m., 1 ♀ ovig.

Distribution.—The var. *indica* is only known from the Kei Is. at 310 m. The type of *P. longipes* was obtained at Barbados, 365 m.

Remarks.—The single specimen is of large size (carapace 37·5 mm., total length about 183 mm.), and in all characters that can be examined it agrees excellently with de Man's detailed description and figures. All the posterior legs, however, are mutilated or wanting, so that the measurements of these, required to separate this species from its neighbours in de Man's key, cannot be obtained. It is not clear, however, that the "var. *indica*" of de Man is more closely related to the West Indian *P. longipes* than it is to some of the Indo-Pacific forms.

Plesionika sindoi, Rathbun.

Rathbun, 1906, p. 915, pl. xxi, fig. 4; de Man, 1920, p. 126, pls. xi and xii, figs. 27–27*e*; Balss, 1925, p. 279, pl. xxvi, text-figs. 49–52.

Occurrence.

Gulf of Aden:

St. 177, trawl, 274–366 m., 2 ♀ ovig.

Distribution.—Nicobar Is., Sulu Sea and Kei Is., Hawaii, 109–622 m.

Remarks.—The specific name given above is only applied to these specimens with much dubiety. They have the legs of the second pair equal, the rostrum long ($1\frac{1}{2}$ to $1\frac{2}{3}$ of the carapace), toothed above and below, and the dactylus of the fourth leg about $\frac{1}{15}$ of the propodus. According to de Man's key, therefore, they come into the neighbourhood of *P. longirostris* (Borradaile) and *P. sindoi* (Rathbun). According to Borradaile's figure (1900, pl. xxxvii, fig. 10*a*) the rostrum in his species has very numerous (over 30) teeth above and below, of which three or four are on the carapace. The statement that all the teeth are movable is not likely to be correct. The sixth abdominal somite is shown as equal to the telson and more than twice as long as the fifth. In our specimens the rostral

formulæ are $\frac{5+16}{13}$ and $\frac{6+14}{8}$, beginning with a group of 4 or 5 small close-set, movable (or at least apparently socketed) teeth on the carapace ; the sixth abdominal somite is not quite twice the fifth, and a little shorter than the telson.

Miss Rathbun's description of her species is brief, and her figure (a photograph) shows very little. She mentions, however, the group of small, close-set, dorsal teeth, and the sixth abdominal somite twice as long as the fifth and equal to the telson. She thinks this may be the *P. ocellus* of Alcock, not of Bate, the latter being distinguished, among other things, by the shorter sixth abdominal somite.

De Man gives a detailed account of three specimens which he refers to *P. sindoi* and which, on the whole, agree with our specimens, although the rostral formula is only $\frac{5+9}{6}$. He gives the length of the dactylus of the fourth leg as $\frac{1}{11}$th of the propodus, and of the fifth about $\frac{1}{14}$th.

Balss refers to the same species two specimens much larger than those described by the previous writers (carapace length 30 and 17 mm. respectively). The rostral formula is apparently $\frac{4+21}{24}$, the sixth abdominal segment is twice as long as the fifth and a little longer than the telson. A difference that may be important is that the dactylus of the fifth leg is only little less than one-sixth of the propodus.

Plesionika bifurca, Alcock and Anderson.

P. bifurca, Alcock and Anderson, 1894, p. 155 ; de Man, 1920, p. 136, pl. xii, figs. 31–31*b* ; Balss, 1925, p. 279.
Pandalus (*Plesionika*) *bifurca*, Illustr. " Investigator ", 1901, pl. li, fig. 6 ; Alcock, 1901, p. 98.

Occurrence.

Gulf of Aden :

St. 34, trawl, 1022 m., 1 ♂, 6 ♀ and young.
St. 193, trawl, 1061–1080 m., 1 ♂, 3 ♀ ovig., 2 ♀.

Zanzibar area :

St. 108, trawl, 786 m., 1 ♂.
St. 109, trawl, 640 m., 1 ♀ ovig., 1 ♀, 1 ♂, 5 young.

Maldive area :

St. 158, trawl, 786–1170 m., 1 ♂, 3 ♀.

Distribution.—E. Africa, Laccadive Is., Bay of Bengal, Andaman Sea, Malay Archipelago to Kei Is., 330–1160 m.

Remarks.—The specimens agree in detail with the descriptions of previous authors, the variations falling within the limits given by de Man, except that one female has five dorsal teeth behind the orbit. The largest specimen, an ovigerous female, has the carapace measuring 12 mm. De Man records one of 15 mm.

Plesionika minor, n. sp. (Text-fig. 2.)

Occurrence.

Gulf of Oman :

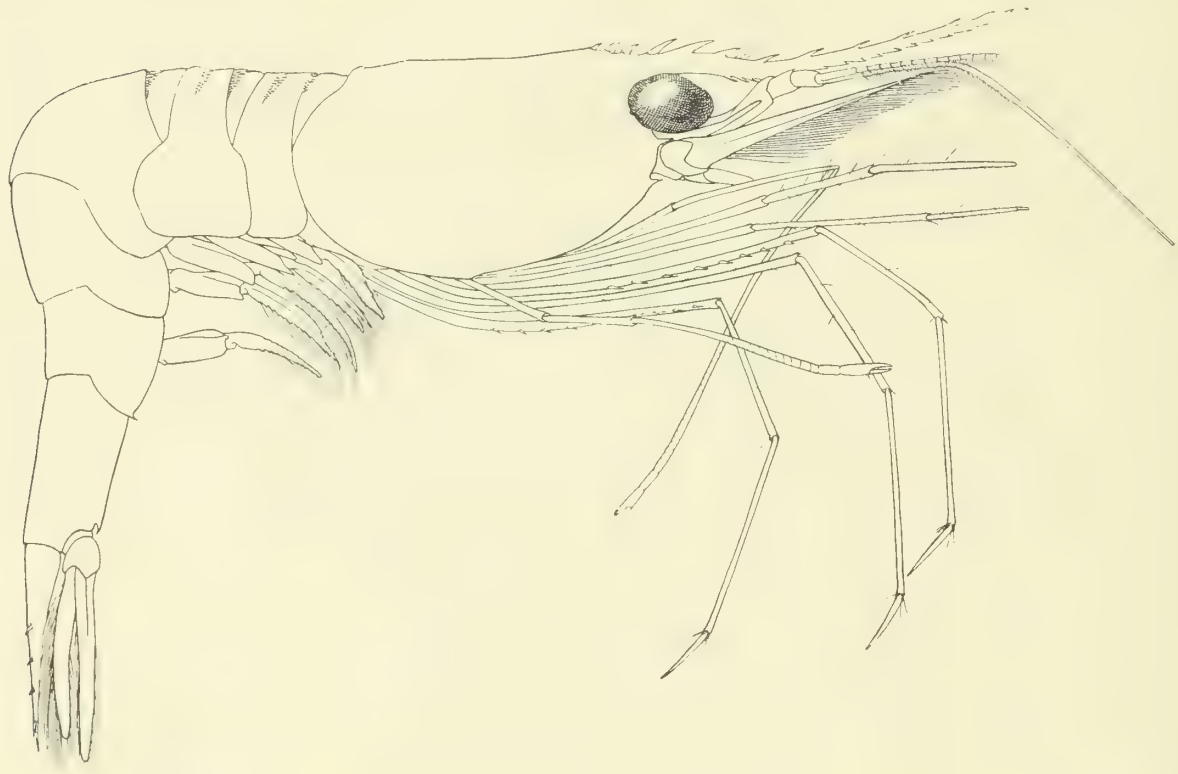
St. 75, trawl, 210 m., 20 sp. (none ovigerous).

Description.—A small species (total length not exceeding 35 mm.) characterized by asymmetrical second legs, very long dactyli of posterior legs, strongly humped abdomen and epipods only on the first two pairs of legs.

Rostrum longer than the carapace by about one-third, with 11–13 teeth above, of which 3 or 4 are behind the orbital notch, a few of the proximal ones articulated ; below there are 10–17 teeth. Third abdominal somite as seen from the side very strongly arched above so that the abdomen appears incapable of complete extension. Sixth abdominal somite more than half as long again as the fifth in large specimens, twice as long in smaller ones, a little shorter than the telson. Posterior angle of pleura of fifth somite with apex bent downwards.

Ocellus distinct. Antennal scale reaching about two-thirds of the length of the rostrum, more than four times as long as wide.

Third maxilliped extending beyond antennal scale by less than half its last segment



Text-fig 2.—*Plesionika minor*, sp. n. St. 75, ♀ Holotype.

which is longer than the penultimate by about one-third. First leg extending to tip of third maxilliped, last segment less than two-thirds of preceding, with a microscopic chela. Second legs very unequal, the right a little shorter than first leg, the left nearly twice as long, carpus of right with about 15 segments becoming indistinct towards the base. Third leg with merus extending to middle of penultimate segment of third maxilliped, with about 8 spines below ; propodus not $1\frac{1}{2}$ times as long as carpus, dactylus curved, slender, one-third of propodus. The whole limb outreaches the rostrum by more than the dactylus. Fourth and fifth legs not differing much from third in size or proportions. Merus of last leg with about 10 spines.

Holotype, female, not ovigerous. Measurements (in mm.), total length about 27, carapace 5·25, rostrum 7, abd. som. v 1·3, abd. som. vi 2·7, telson 3·3.

Remarks.—In having epipods on the first two pairs of legs only this species is intermediate between the genera *Plesionika* and *Parapandalus*.

Parapandalus Zurstrasseni, Balss.

Balss, 1914*c*, p. 597 ; de Man, 1920, p. 141, pl. xii, figs. 32–32*d* ; Balss, 1925, p. 281, pl. xxvii, text-figs. 53–59.

Occurrence.

Central part of Arabian Sea.

St. 96, 2 m. net, 400–645 m. (sounding 4459 m.), 1 ♀ ovig., 1 ♂.

St. 172, 2 m. net, 2091–0 m. (sounding 4720 m.), 1 ♀.

Distribution.—Seychelles, between Cocos Is. and Sumatra, Malay Archipelago. From 1000–2400 m. to surface.

Remarks.—The total length of the male is about 52 mm., carapace 7·25 mm., rostrum 22 mm. The body and limbs of the specimen from St. 172 are rather heavily pigmented with dark brown, but it is possible that this is due to staining after death.

Parapandalus Adensameri, Balss.

Balss, 1914*b*, p. 134 ; 1915, p. 18, text-fig. 17 ; de Man, 1920, p. 139.

Occurrence.

Red Sea :

St. 208, dredge, 732–805 m., 9 specimens.

Gulf of Aden :

St. 35, trawl, 457–549 m., many specimens.

Maldive area :

St. 145E, trawl, 494 m., 1 ♀.

Distribution.—Red Sea, 805–1308 m.

Remarks.—The specimens agree very satisfactorily with the description and figure of Balss. De Man, apparently relying on Balss's figure, states that the sixth abdominal somite is only half as long again as it is deep. In our specimens it is twice as long or only a trifle less. If this correction be applied, de Man's key would bring the species into comparison with the Mediterranean *P. narwal* (Heller). Heller's species is represented in the Norman collection by ten specimens from Barcelona, and in these I find minute but distinct epipods on the legs (except the last pair) so that according to the accepted definitions the species should be referred to the genus *Plesionika*. Apart from this character, however, *P. narwal* is distinguished from *P. Adensameri* by the much shorter posterior legs which do not reach the tip of the rostrum, and have, in the fifth pair, the carpus much shorter than the propodus.

Parapandalus spinipes (Spence Bate).

De Man, 1920, p. 142, pls. xii and xiii, figs. 33–33*e* (with synonymy) ; Chilton, 1911, p. 547.

Occurrence.

Red Sea :

St. 208, dredge, 732–805 m., 2 ♂ imperfect,

Gulf of Aden :

St. 16, trawl, 186 m., many ♂, ♀ and young.

Zanzibar area :

St. 105B, trawl, 238–293 m., many ♂ and ♀.

Distribution.—Cape Comorin, Malay Archipelago, N. of New Guinea, Japan, 110–300 m. Chilton records a specimen washed up on the beach at the Kermadec Is.

Remarks.—The largest specimen, an ovigerous female, measures about 112 mm. in total length. The agreement with de Man's description is very close. The number of teeth on the lower edge of the rostrum is sometimes larger than in de Man's specimens, reaching about 40. The dactylus of the posterior legs is relatively a little longer than in de Man's Malayan specimens, but is apparently about equalled by the Japanese specimens measured by him.

Since Balss (1915, p. 19) has recorded the Mediterranean *P. pristis* (Risso) from the Red Sea it is perhaps of significance that our two specimens from the Red Sea seem to approach that species in the more slender sixth abdominal somite (length 9·1, width 2·2, height 4·5 mm.), which is only a little shorter than the telson (10·25 mm.). They are of small size and much damaged, and I am unable to convince myself that the small differences of proportion observed when they are compared with specimens of *P. pristis* of similar size are of specific value. On the dorsal surface of the carapace at about one-sixth of its length from the hinder edge there is a minute tubercle, barely perceptible in many of the specimens. This corresponds in position to the " small blunt median spine " described by Miss Rathbun in the West Indian *P. longicauda*.

Parapandalus filipes, sp. n. (Text-fig. 3.)

Occurrence.

Red Sea :

St. 5, 2 m. net, oblique haul 500–0 m. (sounding 938 m.), many specimens.

South Arabian Coast :

St. 76B, 1 m. net, 600 m. Many specimens ; 1 m. net, 1500 m., 2 specimens ; and 2 m. net, 2500 m., many specimens (sounding 3289 m.).

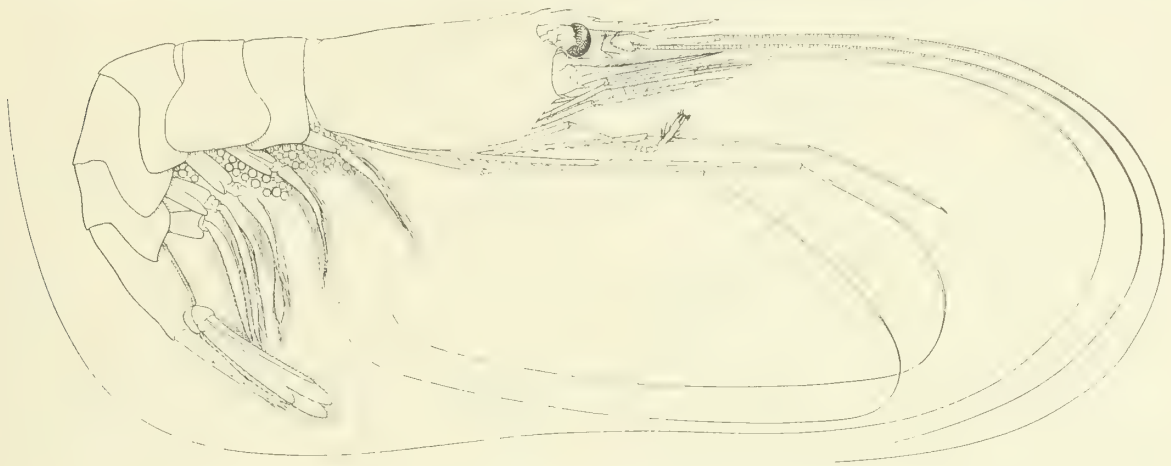
Description.—Integument thin and soft. Carapace without distinct ridges on the sides, but with a doubly crescentic branchial groove. Carapace and, less conspicuously, the abdominal somites and some, at least, of the appendages, covered with minute deciduous scale-like setæ (" phanères en forme d'écailles " Coutière). Rostral crest beginning about the middle of the length of the carapace. Rostrum slightly shorter than the carapace and reaching to about the tip of the antennal scale, slender, curving gently downwards from the base and upwards to the tip ; 7 or 8 teeth dorsally, of which 2 or 3 are behind the orbit and the distal one about level with the end of the antennal peduncle; beyond this the dorsal edge is smooth to the tip ; 7 to 9 teeth below, the proximal ones very minute and hidden by a fringe of long hairs. Of the dorsal teeth the proximal 3 or 4 are more or less obscurely socketed, the remainder fixed. Abdominal somites rounded above, none produced into teeth. Sixth somite twice as long as the fifth and equal to the telson, which is shorter than the rami of the uropods.

Eye without distinct ocellus. Antennule with peduncle not reaching middle of rostrum, its lateral process acute and not reaching beyond the end of the first segment ;

its flagella exceed the total length of the body. Antennal scale about five times as long as its greatest width ; flagellum at least twice the length of the body.

Third maxilliped exceeding antennal scale by half of its last segment, which is about three-quarters as long as the preceding.

First leg extending to tip of antennal scale, last segment (propodus and dactylus) less than half length of preceding ; no chela. Second legs equal, extending to base of last segment of first legs, about 12 segments in the carpus, the proximal ones indistinct. Third legs with merus reaching one-third of penultimate segment of first legs, with about 13 spines below ; carpus extending by half its length beyond the rostrum, a little longer than propodus ; dactylus about one-seventeenth of length of propodus. Fourth and fifth legs very long and of thread-like tenuity. The merus of the fourth reaching to base of penultimate segment of first leg, with about 9 spines below, its carpus reaching as far as carpus of third leg, propodus and dactylus not differing greatly in proportions from those of fifth leg. Fifth leg with merus reaching to middle of merus of fourth, without spines,



Text-fig. 3.—*Parapandalus filipes*, sp. n. St. 76*b*, ♀ Holotype.

carpus reaching to middle of carpus of fourth, propodus about four times as long as carpus, excessively attentuated, not segmented ; dactylus microscopic.

Holotype, an ovigerous female from St. 76B. Measurements (in mm.) : Total length about 40, carapace 9, rostrum 8, abd. som. v 2·75, abd. som. vi 5·75, telson 5·5, peræopod v carpus 8, propodus 30.

Remarks.—This species is characterized by the extreme length and slenderness of the last two pairs of legs. They are rarely found undamaged in the present collection, and legs of both pairs were never found attached to the same individual. It is therefore impossible to state their relative lengths, although I believe from comparison of specimens of similar size that the fourth pair are slightly longer than the fifth.

Dorodotes reflexus, Spence Bate.

Spence Bate, 1888, p. 678, pl. cxvi, figs. 3, 3*a* ; Wood-Mason and Alcock, 1891*a*, p. 195 ; Alcock, 1901, p. 109 ; de Man, p. 152.

Occurrence.

Northern area of Arabian Sea :

St. 62, trawl, 1893 m., 1 ♂.

Maldive area :

St. 155, trawl, 2249 m., 1 ♂.

St. 162, trawl, 1829–2051 m., 1 young.

Distribution.—Bay of Bengal, Banda Sea, Philippines, 1920–3006 m.

Remarks.—Our specimens are all imperfect, but they agree with the descriptions of Alcock and de Man and with Bate's types. The segments of the carpus of the second legs which de Man found to be 10 are 8 and 9 in two of the present specimens.

Heterocarpus Wood-Masoni, Alcock.

Alcock, 1901, p. 108 ; Illustr. " Investigator ", 1901, pl. li, fig. 2 ; de Man, 1920, p. 156, pl. xiii, figs. 36–36*c*; Balss, 1925, p. 286.

Occurrence.

Zanzibar area :

St. 105B, trawl, 238–293 m., 8 ♀ ovig., 67 immature.

St. 109, trawl, 640 m., 1 immature.

Distribution.—E. African coast, Andaman Sea to Kei Is., 289–638 m.

Remarks.—The material comprises 8 large ovigerous females (carapace length 24·5 to 29 mm.) and a large number of small, apparently immature specimens (c.l. 8 to 13 mm.). None of the latter show male characters.

The specimens agree in almost every particular with de Man's detailed description. The most important divergences are that (*a*) in adults as well as in young, the gastric portion of the dorsal crest, bearing the first two rostral teeth, is much more elevated than in de Man's figures ; and that (*b*) in all specimens the telson has two pairs of dorsal spinules instead of four pairs as stated by de Man. The range of variation in the rostral formula slightly exceeds the limits given by de Man.

Heterocarpus longirostris, MacGilchrist.

MacGilchrist, 1905, p. 237 ; Illustr. " Investigator ", 1905, pl. lxxi, figs. 2 and 2*a* ; Balss, 1925, p. 286.

Occurrence.

Maldive area :

St. 159, trawl, 914–1463 m., 1 ♀.

Distribution.—Bay of Bengal, 1754 m. Off Nias Is., Sumatra, 1143 m.

Remarks.—The specimen agrees closely with the original description and with the figure quoted above. It slightly exceeds the measurements given by MacGilchrist for his two male specimens (carapace length 35 mm.). As in Balss's still larger female, the post-ocular carina is more strongly marked than in the original figure.

Heterocarpus tricarinatus, Alcock and Anderson.

Alcock and Anderson, 1894, p. 154 ; Illustr. " Investigator ", 1901, pl. li, fig. 1 ; Alcock, 1901, p. 107 ; Stebbing, 1914, p. 39 ; de Man, 1920, p. 161, pls. xiii and xiv, figs. 38–38*d* ; Balss, 1925, p. 287.

Occurrence.

Gulf of Aden :

St. 185, trawl, 2000 m., 1 ♀.

South Arabian Coast :

St. 54, trawl, 1046 m., 1 sp. (imperfect).

Northern area of Arabian Sea :

St. 62, trawl, 1893 m., 4 ♀, 3 ♂, 7 young.

Zanzibar area :

St. 115, trawl, 640–658 m., 1 ♀ (ovig.), 2 ♀, 1 young.

Maldive area :

St. 145E, trawl, 494 m., 2 ♀, 3 ♂, 2 young.

St. 162, 1829–2051 m., 1 ♀, 1 ♂.

Distribution.—Arabian Sea, Cape, S. of Celebes, 566–1627 m.

Remarks.—Previous authors seem to have found no difficulty in distinguishing between *H. tricarinatus* and *H. gibbosus*, Spence Bate. I am unable to share their confidence, especially since they are not agreed as to the characters on which the distinction is to be based. The type specimen of *H. gibbosus* is not now in a condition to supply any information. Alcock and Anderson, in describing *H. tricarinatus*, lay stress on " the indistinctness of the lower lateral carina, which fades completely before reaching the posterior half of the carapace ". Alcock, in 1901, attaches special importance to the fact that " the abdominal terga, even the third, are quite smooth and non-carinate ", whereas in *H. gibbosus* the third tergum has " a very broad, blunt median carination ". De Man, in his key (1920, p. 155) separates the species by the number of teeth on the upper margin of the " rostrum proper ", that of *H. tricarinatus* having 7 or 8 and that of *H. gibbosus* only 2 or 3. As regards the first point de Man's figure 39*b* shows a carapace of *H. gibbosus* with the lower carina very little longer than in his fig. 38, which represents *H. tricarinatus*. He also figures (fig. 38*a*) a " broad, blunt median carination " on the third abdominal tergum of *H. tricarinatus*. As regards the serration of the rostrum, the height of the dorsal crest sometimes makes it not easy to decide how many of the teeth are to be allotted to what de Man calls the " rostrum proper ". In his description of *H. gibbosus* he states that the dorsal crests may bear 5 to 7 teeth, and the rostrum 1 to 4, giving a possible total of 11. In his specimens of *H. tricarinatus* the total was 14–15, while Alcock gives " at least " 12.

Finally it is to be noted that all authors have found *H. gibbosus* to be a commoner species than *H. tricarinatus*.

The specimens in the present collection are referred to *H. tricarinatus* because in most of them the lower or antennal carina fades out about the middle of the carapace, and the teeth on the dorsal crest and the rostrum together usually number 12 and may rise to 14. Nevertheless, many of them resemble the figures of *H. gibbosus* in the strongly upturned rostrum and the high dorsal crest, the number of dorsal teeth may fall to 10, and in one specimen (young and not in good condition) from St. 145, the antennal carina runs for about three-quarters the length of the carapace. The carina on the third abdominal somite usually resembles that figured by de Man for *H. tricarinatus*, but in some individuals it is defined only by a pair of barely perceptible crescentic grooves, approximating to Alcock's description of the abdominal terga as " quite smooth ".

Heterocarpus Sibogæ, de Man.

de Man, 1920, p. 169, pl. xiv, figs. 42–42*i* ; Balss, 1925, p. 286.

Occurrence.

Maldive Area :

St. 149, dredge, 238 m., 1 ♀.

Distribution.—Nicobar Is. to Kei Is., 289–560 m.

Remarks.—The single specimen agrees so closely with de Man's detailed description and figures that I do not hesitate to record it under this name. In particular the crests on the first and second abdominal somites are very like those shown in de Man's fig. 42*b*, and the teeth of the dorsal crest extend clearly behind the middle of the carapace. I am by no means certain, however, that this species can be kept as distinct from the widely distributed *H. ensifer*, A. Milne-Edwards. The " Challenger " specimens referred by Spence Bate to the latter species have crests on the first two abdominal somites only a little less pronounced than those of the present specimen, and although the abdominal spines are shorter and the dorsal serrations of the carapace do not extend quite so far back, such differences seem an unsafe basis for specific distinction.

Heterocarpus dorsalis, Spence Bate.

Spence Bate, 1888, p. 630, pl. cxi ; de Man, 1920, p. 171, pl. xv, figs. 43–43*g* ; Balss, 1925, p. 285 text-fig. 66.

H. Alphonsi, Spence Bate, 1888, p. 632, pl. cxii, fig. 1 ; Wood-Mason and Alcock, 1891, p. 196, and 1892, p. 367 ; Alcock, 1901, p. 106 ; Stebbing, 1914, p. 40.

Occurrence.

Gulf of Aden :

St. 34, trawl, 1022 m., 11 very young.

St. 193, trawl, 1061–1080 m., 5 immature.

Zanzibar area :

St. 119, trawl, 1207–1463 m., 3 very young.

Distribution.—E. Africa and Natal to Philippines and Japan, 185–1325 m.

Remarks.—All the specimens are immature, the largest having the carapace 12 mm. long, while some are only half that size. They agree in most respects with this widely distributed species, although in some, from Stns. 34 and 193, the second tooth of the dorsal crest is set directly over the back of the orbit.

An examination of the type specimens of *H. dorsalis* and *H. Alphonsi* in the " Challenger " collection reveals no grounds for separating these species. De Man hesitatingly suggests that *H. Alphonsi* may stand " as a variety of *H. dorsalis*, distinguished by the longer rostrum and by the upper margin being, as a rule, only armed with 9 or 10 teeth, 2 of which stand on the carapace ". The two syntypes of *H. dorsalis*, however, have each only 8 dorsal teeth, of which 2 are on the carapace. The relatively longer rostrum is by no means a well-marked distinction, even if its application were not made difficult by frequent damage to the tip. One of the syntypes of *H. Alphonsi* has the carapace 21·5 mm. and the rostrum 37 mm. long. In one of de Man's specimens referred to *H. dorsalis* the corresponding measurements are 21 and 35·5 mm.

It is possible, and even probable, that it may be possible to distinguish local races or

subspecies of this widely ranging species. A hint of this is perhaps given in the present collection by the fact that a number of the specimens from the Gulf of Aden have only a single dorsal tooth clearly behind the orbit. At present, however, the number of adult specimens available for comparison from different localities is quite inadequate to establish such distinctions.

Heterocarpoides levicarina (Spence Bate).

Dorodotes levicarina, Spence Bate, 1888, p. 680, pl. cxii, fig. 5 ; Henderson, 1893, p. 436 ; Balss, 1915, p. 20.
Heterocarpus (*Heterocarpoides*) *levicarina*, de Man, 1917, p. 284 ; de Man, 1920, p. 178, pl. xv, figs. 44–44*f* ; Kemp, 1925, p. 275.

Occurrence.

Gulf of Oman :

St. 72, trawl, 73 m., 3 ♀ ovig., 1 ♀.

Distribution.—Red Sea, Gulf of Martaban, Malay Archipelago, Arafura Sea, 31–274 m.

Remarks.—Although three of the specimens are ovigerous they are smaller than the " Challenger " types and the specimen recorded by Henderson, with which I have compared them. In one of the ovigerous specimens the total length is about 35, the carapace length is 9·5, and the rostrum 6·5 mm. In all of them the integument is soft and the carination of the carapace hard to discern. The microscopic " shagreen " texture mentioned by Kemp is, however, quite distinct.

Chlorotocus crassicornis (Costa).

Pandalus crassicornis, Costa, 1871, p. 90, pl. ii, fig. 2.
Chlorotocus gracilipes, A. Milne Edwards, 1882, p. 14 ; 1883, pl. xvii.
C. gracilipes var. *andamanensis*, Alcock and Anderson, 1899, p. 284 ; Alcock, 1901, p. 101.
C. crassicornis, Senna, 1904, p. 1, text-fig. ; Stebbing, 1914, p. 42, pl. lxxv ; Calman, 1925, p. 16.

Occurrence.

Zanzibar area :

St. 106, trawl, 183–194 m., 1 ♂, 1 ♀ ovig.

St. 107, trawl, 421–457 m., 1 ♀ ovig., 1 ♀.

Distribution.—Mediterranean, Cape, Natal, Andaman Sea, to 597 m.

Remarks.—Alcock and Anderson, relying on Milne Edwards' figure, regarded their specimens from the Andaman Sea as constituting a variety of the Mediterranean species, the " only obvious difference " (Alcock, 1901) being that the pleura of the last two abdominal somites were acutely produced in their specimens instead of rounded as in the figure. In this and in all other respects I have failed to discover any difference likely to be significant between the present specimens and others from South Africa and from the Mediterranean with which I have compared them. The fifth pleura are minutely acuminate behind, and the sixth somite has a small spine at the hind corner below.

Spence Bate (1888) gives the locality of Milne-Edwards' *C. gracilipes* alternatively as " Gulf of Gascony " (p. 674), and " West Indies " (p. 681). Actually it was taken off the Mediterranean coast of Morocco.

Synalpheus Gravieri, Coutière.

De Man, 1911, p. 216 (with refs.) ; 1915, pl. vi, figs. 25–25*b*.

Occurrence.

Gulf of Aden :

St. 27, trawl, 37–91 m., 1 sp.

South Arabian coast :

St. 45, dredge, 38 m., 18 sp.

St. 53, dredge, 13·5 m., 3 sp.

Distribution.—Red Sea, Maldives, Ceylon, Malay Archipelago, China Sea, Japan, 0–91 m.

Synalpheus fossor (Paulson).

Alpheus fossor, Paulson, 1875, p. 103, pl. xiii, figs. 5–5*g*.
Synalpheus fossor, Coutière, 1905, p. 872, pl. lxx, figs. 6 and 6*a*.

Occurrence.

Red Sea :

St. 10, trawl, 55 m., 4 sp.

Distribution.—Red Sea, Maldives.

Synalpheus trispinosus, de Man.

De Man, 1910, p. 300 ; de Man, 1911, p. 288, 1915, pl. xii, figs. 58–58*f*.

Occurrence.

Gulf of Aden :

St. 24, dredge, 73–200 m., 1 ♀.

No locality, 1 ♀ ovig.

Distribution.—Java.

Alpheus spongiarum Coutière.

De Man, 1911, p. 362 (with refs.).

Occurrence.

Red Sea :

St. 10, trawl, 55 m., 1 ♂.

Distribution.—Red Sea, Ceylon, Malay Archipelago, Torres Straits.

Alpheus macrosceles, Alcock and Anderson.

De Man, 1911, p. 403 (with refs.).

Occurrence.

Gulf of Aden :

St. 34, trawl, 1022 m., 6 ♂, 8 ♀.

St. 176, trawl, 655–732 m., 1 ♂.

St. 188, trawl, 528 m., 1 ♂.

St. 193, trawl, 1061–1080 m., 2 ♀.

Distribution.—Bay of Bengal, Andaman Sea, Bali Sea, 330–401 m.

Alpheus euchirus, Dana.

De Man, 1911, p. 434 (with refs.).

Occurrence.

Red Sea :

St. M.B. I(*b*), dredge, 26 m., 2 ♂.

St. M.B. I(*c*), dredge, 26 m., 26 sp., 1 ♀ ovig.

Distribution.—Red Sea, Malay Archipelago.

Merhippolyte Calmani, Kemp and Sewell.

Kemp and Sewell, 1912, p. 20, pl. i, figs. 1–4 ; Kemp, 1914, p. 88.

Occurrence.

Maldive area :

St. 145, trawl, 494 m., 2 ♀ (1 ovig.).

Distribution.—Off Malabar, 432 m.

Remarks.—The two specimens agree closely with the descriptions and, in particular, show all the characters mentioned by Kemp (1914) as distinguishing the species from the closely allied *M. kauaiensis*, Rathbun.

The species has not been recorded since its first description, and it may be significant that it has again been found in the same region and at nearly the same depth.

Ligur Edwardsii, Sarato.

Senna, 1903, p. 321, pl. xvii, figs. 1–17, text-fig. 6 ; Gordon, 1936, p. 107, text-fig. 2.

Occurrence.

Maldive area :

St. 145, trawl, 494 m., 1 ♂.

Distribution.—Mediterranean, Nice (? depth), off S. Sardinia, 656–860 m.

Remarks.—The single male specimen is somewhat damaged. The carapace length is 13·25 mm. and the total length about 50 mm.

On the side of the carapace is a well-marked longitudinal ridge which, starting from the hind margin about the top of the branchial region, runs straight forwards except for a slight dip about the middle of its length ; from the dip a branch runs downwards and curves forwards before fading out ; at about a quarter of its length from the front the longitudinal ridge bifurcates, the upper branch curving towards the orbital margin, but stopping abruptly before reaching it, and the lower branch being continuous with the antennal spine.

This sculpture of the carapace seemed at first sight to distinguish the specimen sharply from *L. Edwardsii*, in which the carapace is described by Senna as smooth. The two Mediterranean specimens of the species in the Museum collection show, however, a longitudinal ridge which, although almost smoothed away, agrees precisely in position and branching with that just described. According to Senna, the dorsal crest should end about the middle of the carapace. In the two Mediterranean specimens it extends to about the posterior third, and in the Indian Ocean specimen it reaches nearly to the hind margin.

In all other respects the present specimen agrees with the Mediterranean specimens.

There are some slight differences of proportion in the appendages, but these, although a little greater, are of the same order as those between the Mediterranean specimens themselves. The latter are both ovigerous females, 83 and 88 mm. in length respectively, and in view of the differences in sex and size, exact agreement in proportions would hardly be expected. It is, of course, possible and even probable, that comparison of a larger number of specimens would reveal constant distinctions between the Mediterranean and Indian Ocean types. Meanwhile, the use of the same specific name calls attention to the occurrence of very closely allied forms in the two areas.

The only other species referred to the genus *Ligur* is *L. uveæ* (Borradaile), which has been recorded from Aldabra and ranges to the Loyalty Islands and Fiji. As Dr. Gordon has shown, it differs in some remarkable characters from *L. Edwardsii*, and it may be suggested that the genus *Parhippolyte*, of which it is the genotype, might be maintained as distinct from *Ligur*.

Palæmonella vestigialis, Kemp.

Kemp, 1922, p. 123, pl. iii, fig. 2, text-figs. 1, 2 and 7*a*.

Occurrence.

Red Sea :

St. 10, trawl, 55 m., 1 ♀.

Distribution.—Gulf of Suez, Seychelles, Ceylon, Andamans, Mergui.

Remarks.—Except for a few trivial differences of proportion, the specimen agrees minutely with Kemp's description of the typical form of the species. The total length is 10·6 mm., and the rostral teeth are $\frac{8}{2}$. The body and limbs are suffused and blotched with dark brownish red, the distribution of which does not suggest post-mortem staining. Kemp notes that the species is " not conspicuously coloured in life ". (*l. c.*, p. 127.)

Periclimenes (*Periclimenæus*) *arabicus*, sp. n. (Text-fig. 4.)

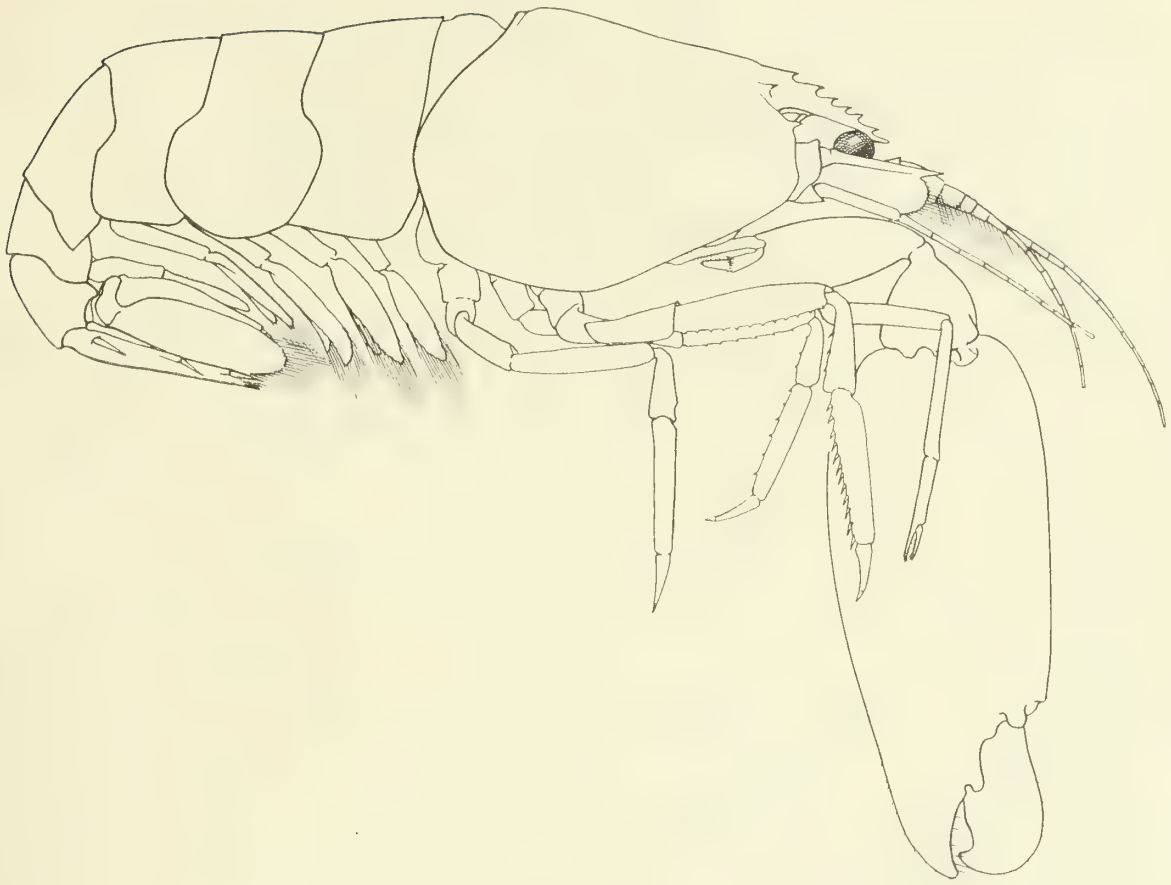
Occurrence.

South Arabian coast :

St. 53, dredge, 13·5 m., 1 ♀. " From surface of Sponge."

Description.—Resembling *P. robustus*, Borradaile (with the fragmentary types of which it has been compared), but differing in the following characters.

The rostrum hardly exceeds the eyes and has 6 teeth above, all in front of the orbital margin. There is a small but well-marked supra-orbital spine. *P. robustus* has, in the same position, only a faint ridge, and the absence of a supra-orbital spine is given by Borradaile as one of the characters of the sub-genus. The antennal spine is small. The spine of the antennal scale projects beyond the lamina. The third maxilliped has the penultimate segment hardly longer than the terminal one. The fingers of the first leg are not more than two-thirds of the length of the palm. In the second legs the palm of the larger chela has the edges nearly parallel as in Borradaile's type, not diverging as in his figure ; the granules on the surface are less prominent and nowhere become spinulose. The smaller chela is not constricted at the base of the movable finger. The walking-legs have the dactylus slender, about one-third as long as the propodus, the secondary claws very small. The third leg has 12 spines on the propodus, and the carpus and merus are



Text-fig. 4.—*Periclimenes* (*Periclimenæus*) *arabicus*, sp. n. St. 53, ♀ Holotype.

also spined below. The fifth leg has no spines on these segments. The telson has the dorsal spines enlarged.

Total length about 14 mm.

Periclimenes (*Ancylocaris*) *crassipes*, sp. n. (Text-fig. 5.)

Occurrence.

South Arabian coast :

St. 45, dredge, 38 m., 2 ♀ ovig. "Animals pulled off calcareous sponges or removed from the debris in the jar containing them."

Description.—Body stout but not depressed, integument thin and rather soft, appendages short and thick, third and fourth pairs of legs remarkably enlarged.

Carapace deeper than wide. Rostrum shorter than first segment of antennular peduncle, little more than one-third of length of carapace, slender, slightly upturned at tip, with four large teeth above, all in front of orbit, toothless below. Antennal spine large, supra-orbital and hepatic absent. Below the antennal spine the anterior margin projects as a broadly-rounded lobe.

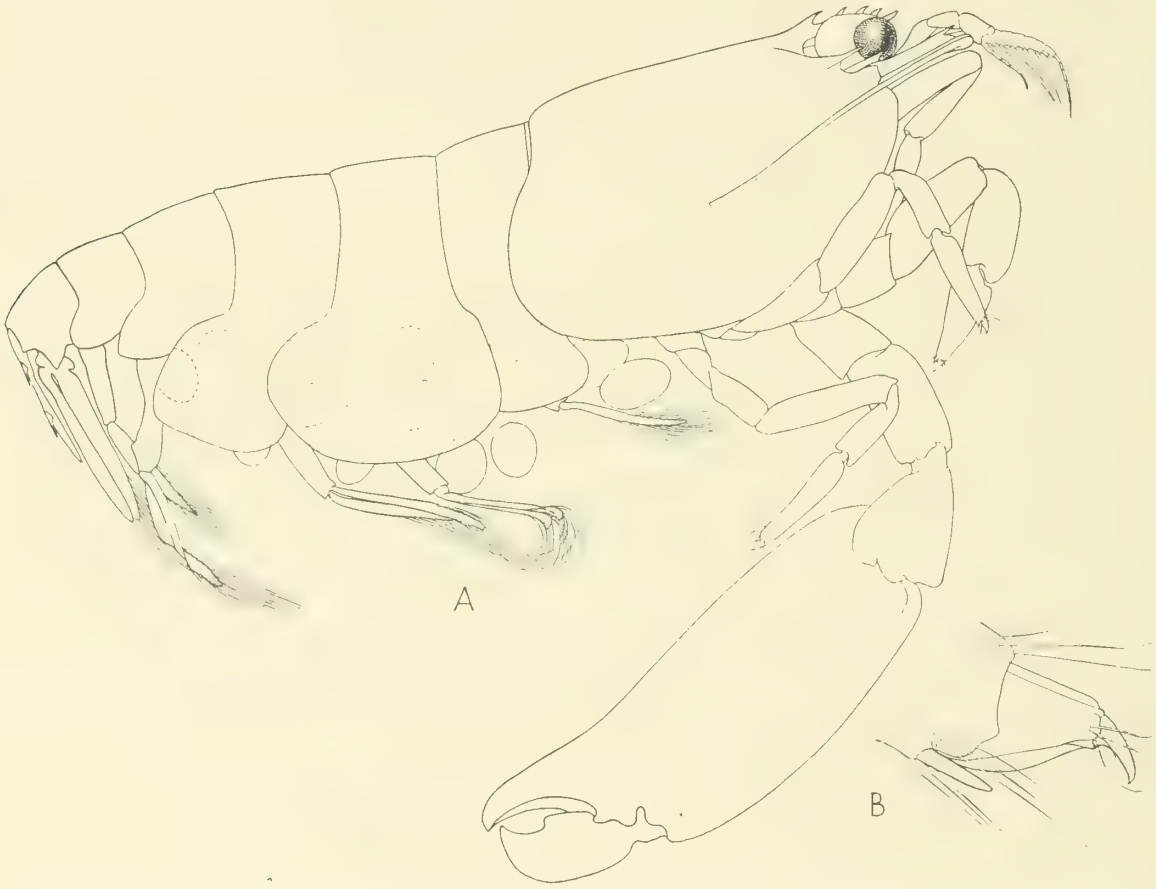
Abdomen smooth, pleura large, distended with eggs, fifth somite longer by a quarter than the sixth, which is equal to the telson.

Eyes with the cornea rather narrower than the peduncle. Antennules with first segment of peduncle longer by one-half than the second and third together, stylocerite

broad, reaching beyond middle of segment, no distal spine, flagella shorter than peduncle. Undivided portion of outer flaegllum about one-half of its total length, of five segments, inner branch very small, unsegmented.

Antenna with scale reaching to end of second segment of antennular peduncle, rounded tip of lamina extending a little beyond external spine, flagellum shorter than carapace. Mandible without palp, inner lacinia of maxillula narrow, all maxillipeds with exopods.

First legs slender, merus, carpus, and hand subequal, fingers straight, little shorter



Text-fig. 5.—*Periclimenes* (*Ancylocaris*) *crassipes*, sp. n. St. 45. A, Holotype. B, Claw of fifth leg, further enlarged.

than palm. Second legs massive, the left the larger in both specimens. In the holotype the hand of the left side longer than carapace, about four times as long as carpus and less than three times as long as wide, dactylus very deep and about two-fifths as long as palm. There is a broad flat-topped tooth on the cutting edge of the dactylus fitting into a pit in the fixed finger. Surface of chela quite smooth.

Third legs very massive and flattened, the carpus about twice as long as wide, half as long as merus and longer than propodus, propodus tapering from a broad base to the short thick dactylus which has a simple claw and no basal protuberance. Fourth legs intermediate in proportions between third and fifth.

Fifth legs slender, carpus three times as long as wide, and more than half as long as merus, propodus longer by two-thirds than carpus, not tapering.

Total length of holotype 10·5 mm.

Remarks.—Following the classification established by Kemp (1922) this species is referred to the genus *Periclimenes*, and, since the claws of the walking legs are simple, to the subgenus *Ancylocaris*. Nevertheless it has a decided resemblance to *P. robustus*, Borradaile, in the subgenus *Periclimenæus*, with its massive claw, the armature of its fingers, and the short thick claws of the walking legs. *P. arabicus*, described above, evidently belongs to the same group of species although it has slender claws and a supra-orbital spine. The new species now described appears to be distinguished not only from the species mentioned, but from all the other Pontoniinæ by the enlargement of the first and second pairs of walking legs. *P. arabicus* and *P. crassipes* were found in association with sponges, and it is possible that *P. robustus* may have similar habits. The close resemblance of these three species, only one of which has simple claws on the walking legs, supports the doubt, hinted at by Kemp, whether *Periclimenæus* deserves the status even of a subgenus.

Pontonides unciger, sp. n. (Text-figs. 6 and 7.)

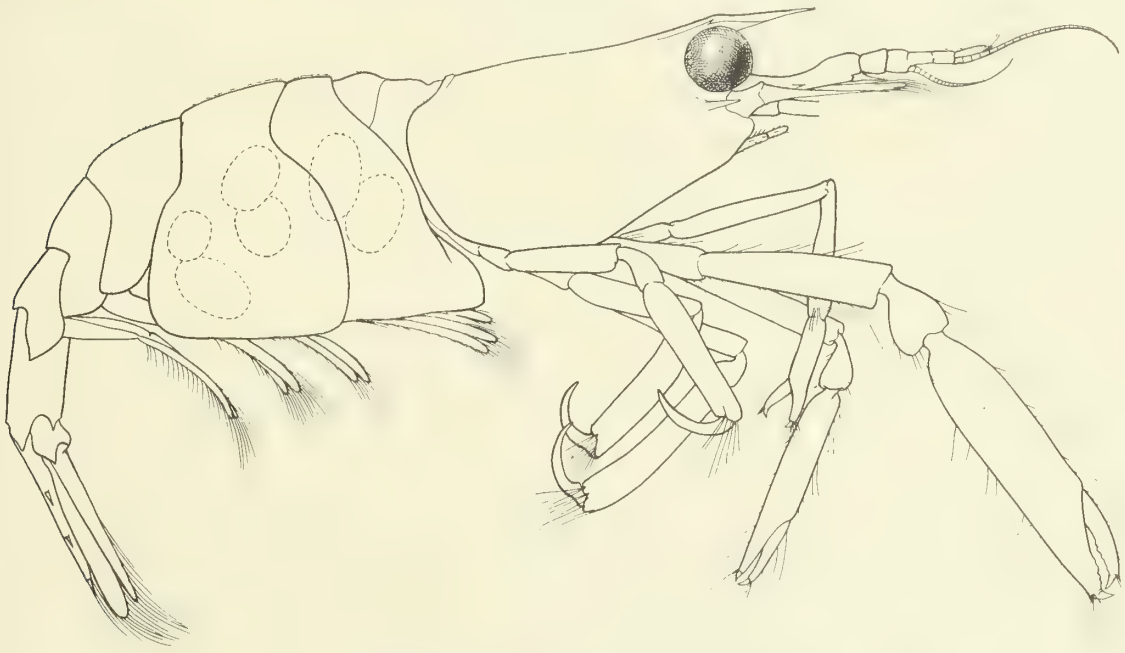
Occurrence.

Red Sea :

St. 10, trawl, 55 m., 1 ♀ ovig.

Description.—Stoutly built, with flattened rostrum and stout walking legs bearing strong curved claws.

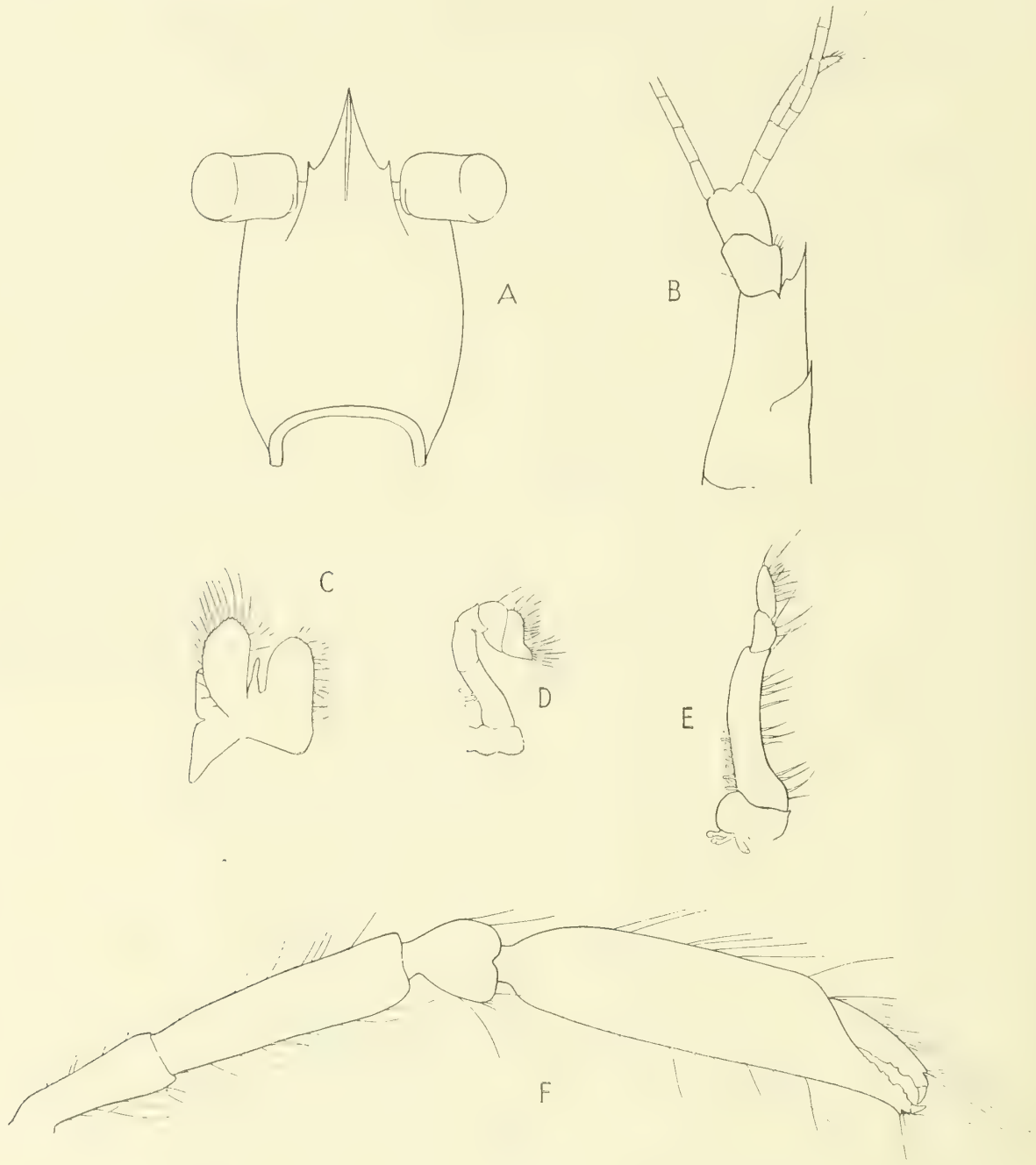
Carapace little deeper than wide. Rostrum three-fifths of length of carapace, barely reaching end of first antennular segment, triangular as seen from above, width at base about three-quarters of its length ; a prominent tooth on each side behind the middle, the sides in front of the tooth gently concave, apex acute ; a prominent median keel extending back to behind the eyes. Orbital margin broadly bevelled off, not defined



Text-fig. 6.—*Pontonides unciger*, sp. n. St. 10. Holotype.

from the surface of the carapace. Antennal spine strong, antero-lateral margin below the spine produced forwards and obtusely pointed.

Abdomen smooth, fifth somite a little less than two-thirds as long as sixth, and less than half as long as telson.



Text-fig. 7.—*Pontonides unciger*, sp. n. A, Carapace, from above. B, Antennule. C, First maxilliped. D, Second maxilliped. E, Third maxilliped. F, Larger leg of second pair.

Antennule with first segment of peduncle broad, extending a little beyond rostrum, stylocerite short, behind the middle, distal spine reaching end of second segment. Second and third segments sub-equal. Flagella short, the inner thick, with uncleft portion of

only two segments and the short ramus, obscurely segmented, about two-thirds as long as the uncleft part. Antennal scale little more than twice as long as wide, distal edge of lamina broadly rounded and extending well beyond the external spine.

Mandible without palp. First maxilliped with exopod broadly rounded, without flagellum. Second maxilliped without trace of exopod, terminal segment with the inwardly directed margin deeply concave. Third maxilliped without trace of exopod, terminal segment three times as long as wide.

First legs extending beyond antennal scale by propodus and half of carpus. Carpus longer than propodus, fingers shorter than palm. Second legs unequal, the larger extending beyond scale by carpus and propodus. Carpus less than half as long as merus, propodus more than four times as long as carpus and about four times as long as wide. Fingers less than two-fifths of palm, straight, hooked at tip, with irregular teeth. Smaller leg more slender, fingers without teeth.

Walking legs short and stout, with large, curved, simple claws. Fifth pair falling short of antennal scale when extended forward, propodus rather more than five times as long as wide, and twice as long as claws.

Total length about 6·7 mm. Length of carapace 1·4 mm.

Remarks.—This species belongs to a little group of Pontoniinæ, comprising, according to Kemp, the genera *Pontonides* and *Balssia*, in which the maxillipeds of the second and third pairs are without exopods or have only vestiges of them. Whether the exopods are also absent from the first pair in *Pontonides maldivensis*, as stated by Borradaile, may be doubted. It seems more likely that Borradaile merely meant to imply the absence, as in the species now described, of the narrow anterior prolongation of the exopod sometimes called the flagellum.

From the genus *Balssia* the present species is excluded by the lack of sculpturing on carapace and abdomen, and by the absence of teeth on the median crest of the rostrum, as well as by the absence of the flagellum from the first maxilliped. It is to be noted that the dentate supra-orbital crests of *Balssia* are just in a position to extend forward to form the lateral wings of the rostrum.

In the Atlantic *P. beaufortensis*, Borradaile, which Kemp includes in *Pontonides*, the rostrum does not seem to be expanded laterally and the antennal scale is " rather acutely pointed ". *P. maldivensis*, Borradaile, resembles the present species in many points, but the rostrum is much more expanded and is without lateral teeth, the third maxilliped is perhaps rather broader, and the dactyli of the walking legs are long and slender.

The body and to some extent the limbs of our specimen are coloured a dark brownish red, like the specimen of *Palæmonella vestigialis* found at the same station.

Pontonia anachoreta, Kemp.

Kemp, 1922, p. 264, text-figs. 93–95.

Occurrence.

Gulf of Aden :

St. 27, trawl, 37–91 m., 2 ♀, 1 ovig.

Distribution.—Madras coast, 36 m. In the Ascidian *Polycarpa Annandalei*, Oka.

Remarks.—The specimens agree with Kemp's account except in the following details. The rostrum is acute in lateral view. The antennal scale is twice as long as wide and the

terminal spine projects well beyond the lamella. The antepenultimate segment of the third maxilliped is less than twice as long as wide, the penultimate is more than twice as long as wide, and longer than the last segment. These proportions suggest a diminution of the differences separating this species from Borradaile's *P. ascidicola* from New Britain. The types of that species, which I have examined, confirm the characters quoted by Kemp from Borradaile, with the addition that the dactylus of the last three legs has 7–8 spines behind the biunguiculate apex.

Glyphocrangon Smithii, Wood-Mason.

Wood-Mason [and Alcock], 1891*b*, p. 357 ; Illustr. " Investigator ", 1894, pl. vii, figs. 3, 3*a* ; Alcock, 1901, p. 129.

Occurrence.

Gulf of Aden :

St. 34, trawl, 1022 m., 1 ♂, 1 ♀, 2 young.

St. 193, trawl, 1061–1080 m., 1 ♂, 1 ♀, 2 young.

Maldive area :

St. 152, dredge, 609–915 m., 1 ♀.

St. 158, trawl, 786–1170 m., 1 ♂.

Distribution.—Maldives, Bay of Bengal, Andaman Sea, 342–1024 m.

Remarks.—The specimens agree in general with the descriptions of this species, but, in addition to the tooth at its anterior end, the dorso-lateral ridge has another just behind the middle of its length and a third close to its hinder end. One specimen (St. 34) has two more teeth intercalated between these. No teeth behind the first are shown in the figures of *G. Smithii*.

The paratype of *G. regalis*, Spence Bate, from Fiji, has a small tooth at the front end of the dorso-lateral ridge and in other respects conforms to the accounts of *G. Smithii* except that the second legs are unequal, the right being longer than the succeeding pairs and reaching beyond the antennal scale.

Glyphocrangon investigatoris, Wood-Mason.

Wood-Mason [and Alcock], 1891*a*, p. 191 ; Illustr. " Investigator ", 1894, pl. vi, fig. 1 ; Alcock, 1901, p. 129 ; (? part) *G. regalis*, Spence Bate, de Man, 1920, p. 220, pl. xviii. figs. 54–54*k*.

Occurrence.

South Arabian coast :

St. 54, trawl, 1046 m., 1 ♀ ovig.

Distribution.—Arabian Sea, Bay of Bengal, Andaman Sea, 258–1087 m.

Remarks.—The single specimen (carapace 27 mm.) agrees closely with two smaller specimens received from the Indian Museum. De Man places this species, with doubt, in the synonymy of *G. regalis*, Spence Bate. The holotype of that species, from Banda, in the " Challenger " collection, differs greatly in general aspect from the specimen now recorded, the granules on the carapace and abdomen being fewer, blunter, and less sharply defined. De Man's figures resemble the " Challenger " specimen more closely than they do the Indian and Arabian specimens.

Glyphocrangon assimilis, de Man.

De Man, 1920, p. 227, pl. xix, figs. 57–57*h*.

Occurrence.

Zanzibar area :

St. 118, trawl, 1789 m., 1 ♀.

Distribution.—Bali Sea, 538 m.

Remarks.—The single specimen is only referred to de Man's species with considerable doubt, since the anterior part of the dorso-lateral crest is obscure, being represented by a row of four low and much eroded tubercles. The crests of the carapace are all low, blunt, and deeply eroded. The eyes are pale on the dorsal surface, although suffused with purple-brown below. The branchial formula is that given by Alcock for *Glyphocrangon*.

Glyphocrangon Mabahissæ, sp. n. (Text-fig. 8.)

Occurrence.

Zanzibar area :

St. 109, trawl, 640 m., 1 ♂.

St. 115, trawl, 640–658 m., about 120 specimens, many ovigerous.

Description.—Rostrum exceeding length of carapace by one-quarter to one-third, grooved above, with a median ridge in the distal half ; with two pairs of spines above, the distal at about the first quarter of its length.

Crests of the carapace prominent, the surface between them smooth except for a varying number of tubercles between the dorsal and subdorsal crests. Edges of the crests minutely punctate. The dorsal crest is strongly serrated throughout its length. The subdorsal crest is cut into three teeth behind the cervical groove and its continuation in front is represented by three dentiform tubercles. The posterior part of the dorso-lateral crest ends in front in a rectangular tooth and there is another tooth, sometimes hardly indicated, behind the middle of its length ; the anterior part is represented by a

Text-fig. 8.—*Glyphocrangon Mabahissæ*, sp. n. St. 115. ♀ Holotype.

sharp crest ending anteriorly in a small acute tooth behind the orbital spine and sloping downwards to the cervical groove, where its hinder end is well below the posterior part of the crest. Both parts of the lateral crest end in front in teeth which are often acute, the anterior one well behind the branchiostegal spine.

The abdomen is well tuberculated, the tubercles becoming depressed, confluent and punctate laterally. The median carina of the first somite is prominent and acutely dentiform ; those of the second and third are not prominent or sharp.

The telson extends beyond the uropods by a quarter of its length ; all its edges are smooth.

The antennal scale is barely twice as long as wide. The second legs are slightly asymmetrical, the right extending to the tip of the antennal scale, the left falling a little short of it.

The eyes vary somewhat in depth of colour in the same gathering. The corneal area is purplish brown posteriorly above and below, shading off in front and laterally to a buff tint.

The branchial formula agrees with that given by Alcock for *Glyphocrangon*.

Holotype, ovigerous female. Measurements (in mm.) : Total length about 72, carapace 15·5, rostrum 20·5.

Remarks.—Following the key given by Alcock (1901, p. 126) to the Indian species of *Glyphocrangon*, these specimens would be identified with *G. Gilesii*, Wood-Mason (1891, p. 193). From the detailed descriptions of that species, however, they differ in having the rostrum constantly very much longer ; the dorsal crest serrated, the posterior part of the subdorsal crest tridentate, and the posterior part of the dorso-lateral with a tooth about its middle ; and the abdominal somites abundantly tuberculated instead of " merely wrinkled ".

With the description and figures of *G. assimilis*, de Man (1920, p. 227), the agreement is still closer, but there are one or two divergences. The most important of these concerns the anterior part of the dorso-lateral crest which, in de Man's specimens, did not extend back to the cervical groove but was continued towards it by a row of two to four granules. De Man's specimens further agreed with *G. Gilesii* in having the rostrum shorter than the carapace.

The constancy of characters in the large number of specimens obtained by the " Mabahiss " strongly suggests that they represent a distinct race, which it may be convenient to distinguish by a systematic name.

Glyphocrangon prionotata, Wood-Mason.

G. prionotata, Wood-Mason [and Alcock], 1891*a*, p. 192 ; Illustr. " Investigator ", 1894, pl. vi, figs. 1, 1*a* ; Alcock, 1901, p. 129 ; de Man, 1920, p. 218 ; (*prionota*) Balss, 1925, p. 295.

Occurence.

Gulf of Aden :

St. 185, trawl, 2000 m., 1 ♂.

Distribution.—Gulf of Aden, Laccadives, 1560–1867 m.

Remarks.—The specimen is much damaged, but it agrees closely with a specimen of this species received from the Indian Museum. The species has already been recorded from the Gulf of Aden by Balss.

Pontophilus indicus, de Man.

P. occidentalis, Faxon, var. *indica*, de Man, 1918, p. 164 ; de Man, 1920, p. 264, pls. xx and xxi, figs. 63–63*v*.

P. gracilis, Wood-Mason, 1891, p. 361 ; Alcock, 1901, p. 115 ; Stebbing, 1905, p. 94, pl. xxv ; Kemp, 1916, p. 356 ; Balss, 1925, p. 296.

? *P. gracilis*, S. I. Smith, 1882, p. 36, pl. vii, figs. 2–3*a* ; 1886, p. 50, pl. xi, figs. 1, 2.

Occurence.

Gulf of Aden :

St. 26, trawl, 2312 m., 5 sp.
St. 34, trawl, 1022 m., 2 sp.
St. 185, trawl, 2000 m., 2 sp.
St. 193, trawl, 1061–1080 m., 4 sp.

Zanzibar area :

St. 109, trawl, 640 m., 1 sp.
St. 115, trawl, 640–658 m., 2 sp.
St. 120, trawl, 2926 m., 1 sp.

Maldive area :

St. 145, trawl, 494 m., 15 sp.
St. 155, trawl, 2249 m., 1 sp.
St. 162, trawl, 1829–2051 m., 1 sp.

Distribution.—East Africa, Cape, Bay of Bengal, Andaman Sea, Malay Archipelago, 410–1301 m.

Remarks.—I have recorded these specimens under the name given by de Man because they agree well with his very detailed description, differing only in the larger size attained by some of them (an ovigerous female from St. 155 is 53 mm. in total length while de Man's largest female was only 48 mm.) and in a number of small differences of proportion which I cannot believe to be of systematic value. I have reduced de Man's trinomial to a binomial form for simplicity's sake, not in order to indicate a strong conviction as to the " specific standing " of the form. De Man (*l.c.*, pp. 264 and 268) was uncertain whether his " var. *indica* " should be attached to the West American *P. occidentalis*, Faxon, or to the Atlantic *P. gracilis*, S. I. Smith, while he considered it probable (as Faxon also did) that some of the species constituting this section of the genus might be " geographical races of one widely distributed form ".

The material accessible to me is not sufficient to provide a solution to this problem. The specimens enumerated above undoubtedly belong to one species. In some the anterior gastric spine of the carapace is distinct although small (as in de Man's fig. 63*e*), while in others it is represented by a microscopic granule (with a still smaller one immediately behind it) so that the specimens only differ from the *P. gracilis* of Alcock (and presumably of Wood-Mason, Kemp and Balss) in having two pairs instead of one pair of spines on the rostrum. Stebbing's *P. gracilis* from the Cape (on the evidence of one of his specimens in the Museum) agrees with those now recorded. I hesitate to refer them to the Atlantic *P. gracilis* of S. I. Smith until specimens can be compared directly.*

All the specimens have a rudimentary exopod in the form of a microscopic papilla

* As a contribution towards a future revision of related species it may be recorded that none of the " Challenger " specimens of *P. gracilis*, Spence Bate (=*P. challengeri*, Ortmann), not even the holotype from Tristan da Cunha, has a spine on the outer side of the merus of the first chelipeds.

on the basis of the first chelipeds. This, however, readily escapes observation, and it must have been much more conspicuous in Kemp's specimens of *P. gracilis*, otherwise he would hardly have based on it the primary division of his key (1916, p. 356) to the Indian species of the genus.

As de Man points out (p. 267), the colour of the eyes seems to be correlated with the depth at which the specimens were taken. In the present collection all the specimens from 494 to 658 metres have the eyes uniformly pigmented ; those from 1022 to 1080 metres have the greater part of the cornea pale but with some pigment posteriorly ; while all the specimens from 1829 to 2926 metres have the whole cornea pale.

De Man's observation (p. 265) that this species has a lateral suture (*linea thalassinica*) on the carapace is confirmed.

Pontophilus incisus, Kemp.

Kemp, 1916, p. 357, pl. viii, fig. 1, text-fig. 1 ; de Man, 1920, p. 278, pl. xxii, figs. 66–66*a*.

Occurrence.

Gulf of Oman :

St. 71, trawl, 106 m., 1 ♂.

Distribution.—Andamans, Malay Archipelago, 3·5–90 m.

Remarks.—The specimen, although small (12 mm.) and not in very good condition, agrees in almost every detail with the descriptions of Kemp and de Man.

Pontophilus angustirostris, de Man.

De Man, 1918, p. 163 ; de Man, 1920, p. 279, pls. xxii and xxiii, figs. 67–67*o* ; Kemp, 1925, p. 342.

Occurrence.

South Arabian coast :

St. 43, trawl, 83–100 m., 10 sp.

Distribution.—Andamans, Nicobars, Malay Archipelago, 13–40 m. and in plankton.

Remarks.—The specimens (including ovigerous females 15 mm. in length) differ from de Man's account in having the sculpturing of the body much less strongly marked. The carinæ of the carapace can, for the most part, only be traced with difficulty, although their arrangement seems to be in accordance with the description. The abdominal somites are practically smooth ; only on the fifth somite can a pair of curved divergent ridges be faintly traced on the dorsal surface, and the sixth somite is flattened dorsally. The rostrum is truncate or concave at the tip, not deeply notched. The *appendix masculina* on the second pleopod of the male is as described by Kemp, but is only half as wide as the endopod. What appears to be the exceedingly reduced vestige of the *appendix interna* on the fifth pleopod of a female bears two long setæ.

Pontophilus modestus, de Man.

De Man, 1918, p. 162 ; de Man, 1920, p. 274, pl. xxii, figs. 65–65*j*.

Occurrence.

Maldive area :

St. 154, trawl, 457 m., 4 ♀ ovig.

Distribution.—Kei Is., 304 m.

Remarks.—These specimens, of which the largest is about 25 mm. long, appear to differ in no noteworthy respect from the larger of de Man's two specimens which he describes as the type. They certainly resemble it much more closely than did the smaller specimen which he referred to the same species.

Ægeon bengalense (Wood-Mason).

Crangon bengalensis, Wood-Mason, 1891*b*, p. 360 ; Illustr. " Investigator " 1895, pl. ix, figs. 1, 1*a* ; *Ægeon* (*Parapontocaris*) *bengalense*, Alcock, 1901, p. 122 ; Kemp and Sewell, 1912, p. 22 ; *Æ. bengalense*, Kemp, 1916, p. 375 ; de Man, 1920, p. 294.

Crangon andamanensis, Wood-Mason, 1891*b*, p. 360 ; Illustr. " Investigator ", 1895, pl. ix, figs. 2, 2*a* : *Ægeon* (*Parapontocaris*) *andamenense*, Alcock, 1901, p. 121 ; *Æ. andamanense*, Kemp, 1916, p. 375 ; de Man, 1920, p. 294 ; Balss, 1925, p. 296.

Occurrence.

Zanzibar area :

St. 105, trawl, 238–293 m., 21 sp.

St. 115, trawl, 640–658 m., 1 sp.

No locality (probably from St. 105), 3 sp.

Distribution.—Zanzibar, S.W. of India, Bay of Bengal, Andaman Sea, 264–811 m.

Remarks.—Wood-Mason and Alcock, in distinguishing *Æ. andamanense* from *Æ. bengalense*, lay stress on the form of the rostrum (only equal to the eyes and with the two pairs of lateral spines close together in the middle), and the bispinose median carina of the second abdominal somite in the former species. Nevertheless, a specimen showing these characters was received from the Indian Museum in 1895 bearing the label " *Crangon bengalense* ".

Kemp, in his key, distinguishes the two species mainly according to the numbers of teeth on the carinæ of the carapace. On this point, however, the statements of authors are conflicting. Taking the three lateral carinæ in order from above downwards, the numbers of teeth are given as follows :

	bengalense.	*andamanense.*
Wood-Mason	5 : 3 : 1	4 : 5 : 2
Alcock and Kemp	4 : 3 : 2	4 : 5–6 : 3
Balss	..	4 : 3 : 1 3 : 2 : 1
Indian Museum specimen, 1895	4 : 3 : 1	..

Of twenty-five specimens in the present collection, twenty-four have the formula 3 : 3 : 1 and one (from St. 105) has 4 : 3 : 1. All have the rostrum of the *andamanense* type, that is to say equal to or shorter than the eyes and with the two pairs of lateral spines close together and remote from the basal spine, and all further agree with *andamanense* in having two spines on the median carina of the second abdominal somite. It seems impossible to discover any correlation between the characters given as distinctive of these two species and I have accordingly placed them under one name.

The largest specimen obtained, a female, measures about 52 mm. in total length.

Ægeon Rathbuni, de Man.

Egeon orientalis, Rathbun, 1906, p. 911, pl. xxiii, fig. 3 (nec *Ægeon orientalis*, Henderson).

Ægeon Rathbuni, de Man, 1918*b*, p. 304 ; 1920, p. 300, pls. xxiv and xxv, figs. 74–74*b*.

Occurrence.

Zanzibar area :

St. 107, trawl, 421–457 m., 4 sp.

St. 109, trawl, 640 m., 1 sp.

Distribution.—Malay Archipelago, 11 m., Hawaiian Is., 521–1463 m.

Remarks.—The largest specimen, a female from St. 107, measuring 31 mm. in total length corresponds almost verbatim with de Man's detailed description, even to the differing numbers of carinal teeth on the two sides of the carapace. This close agreement is noteworthy in view of the great difference in the depth at which the specimens were taken.

Ægeon cataphractus (Olivi).

Stebbing, 1900, p. 50 (with refs.) ; Kemp, 1916, p. 375.

Occurrence.

South Arabian coast :

St. 45, dredge, 38 m., 1 ♂.

Distribution.—Mediterranean, Senegambia, Cape, Karachi, Bombay, Ceylon. To 73 m. Borradaile's record of this species from New Zealand refers to *Æ. Lacazei*.

Ægeon Lacazei (Gourret).

Kemp, 1910, p. 156, pl. xxii, figs. 1–5 (with refs.) ; Calman, 1925, p. 17.
Æ. cataphractus, Borradaile, 1916, p. 90 (*nec* Olivi).

Occurence.

Zanzibar area :

St. 105, trawl, 347–384 m., 1 ♀.

Distribution.—S. W. Ireland, Bay of Biscay, Mediterranean, Cape, New Zealand, 128–758 m.

Remarks.—The specimen agrees closely with specimens from S.W. Ireland and also with the New Zealand specimens recorded by Borradaile as *Æ. cataphractus*.

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B. THE ECOLOGY OF SOLITARY CORALS

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WITH TWO PLATES AND THREE TEXT-FIGURES

B. M.
(N.H.)

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WITH TWO PLATES AND THREE TEXT-FIGURES.

The Flabellidæ and Turbinolidæ were reported on by us in Vol. V of this series, pp. 168–202 (1938); they were assigned to 14 genera and 33 species were determined. The present report deals with the rest of the Madreporaria and concerns 16 genera and 36 species, making a total of 30 genera and 69 species.

The collection is of importance in that there is an abundance of specimens of a few species and a fair series of many, these often collected from several dredgings. Such sets allow a study of the environmental variation in their species and a determination as to the characters which are to be regarded as specific. Where they exist, we have compared our species with the type specimens in the British Museum, where Moseley's and Duncan's coralla may be found and to which sets from the present collection are being now added, as well as the species dealt with in the Reports of the Percy Sladen Expedition to the Indian Ocean, together with those of the Maldive and Laccadive Expedition. We have also greatly benefited by a set of co-types of many of Pourtalès, dredged species from the West Indies most generously sent to us by Dr. Thomas Barbour, the enlightened Director of the Agassiz Museum; these also will be found in the British Museum.

The technique we have adopted has been independent determinations of what corals are species and then a joint consideration, followed by a tabulation of their supposed specific characters. Then followed the search of literature to determine genera and species. This has been materially helped by the fact the senior of us has discussed many species and taxonomic questions with workers on the collections of several modern expeditions, while both of us have examined corals when growing on reefs. We have not generally attempted lists of synonyms. Inadequately described corals—and most named on one or two specimens may be so characterized—had better disappear from literature altogether than be forced under some species to which they have often no relation. This is especially the case with young forms, growth incomplete, such resembling each other in any genus more closely than do the adults.

Family Oculinidæ.

Genus *Madrepora* Linnæus.

(*Vide*, Vaughan, ' U.S. Nat. Mus.,' Bull. 59, 80 [1907]).

Obeying the laws of nomenclature we have to employ the above generic name in place of either *Lophelia*, *Amphelia* or *Diphelia*, all Ed. & H. For unstated reasons Vaughan preferred *M. oculata* as the genotype, the other possible species being *M. prolifera*, the two species subsequently separated by Ed. & H. as representing respectively the genera *Amphelia* and *Lophelia*. Duncan* agreed, distinguishing *Lophelia* by the presence of dissepimental tissues and perhaps tabulæ and the absence of a columella, but he assigned *Diphelia* to this genus.

In the growth-form all three genera agree, and certainly, in a series of our specimens of *M. oculata* from off the west coast of Ireland, there are no conspicuous dissepiments, and the corallite cavities are sometimes completely obliterated, as Vaughan stated, by a secondary deposition of corallum. The inner edges of the larger septa always fuse, and there may arise upon this fusion upstanding pillars forming a pseudo-columella ; thus there is always a shallow calice. Pending further knowledge, including a comparison between the polyps of *M. prolifera* and *M. oculata*, we accept Vaughan's designation of the genus—a course which further appeals when many species are examined. This we were enabled to do, as the British Museum loaned to us their collection, which included not only Moseley's types from the " Challenger ", but miscellaneous specimens of kindred genera and a large collection of *M. prolifera*, of which a special study was made so as to determine the variation of the species. Curiously enough, *M. oculata* was not represented, but we have been able to add a series to the British Museum collection.

Of Moseley's " Challenger " types *arbuscula* was dead, its surface obviously so greatly altered that the description is almost valueless. Unfortunately Alcock† did not help us, his only addition being the statement " no costæ, cœnenchyma dense and very smooth ".

Moseley's *tenuis* depended on a fragment, which might quite well belong to *M. infundibulifera* Duncan,‡ the type of which we are unable to find. We are inclined to regard Moseley's *candida* as a good species, but three additional boxes in the British Museum suggest a wide variation almost parallel to *M. prolifera*. *M. investigatoris* Alcock§ and *exigua* Pourtalès‖ judging by the specimens before us must be accepted, but *carolina*‖ can never be determined from Pourtalès' description and Alcock's *moresbyi*§ scarcely seems to us beyond the limits of variation of *investigatoris* and other species.

Madrepora ramea (Duncan).

Trans. Zool. Soc. VIII, 326, xlvi (1873).

Pieces of two colonies from St. 157, 229 m., coral and rock, would seem to fall within the variation of this species, Duncan's figures of which are admirable in some ways, while his description is so scanty that an account of our specimens may be helpful.

* ' Trans. Zool. Soc.' VIII, 234 (1873).
† ' " Siboga " Exp.' 34 (1902).
‡ ' Proc. Zool. Soc.' 1871, 276, xxiv, 4.
§ ' " Investigator " Rep.' 25, iii, 1 (1898).
‖ ' Cat. Mus. Comp. Zool.' 26, i, 6–7 (1871).

Corallum branches irregularly, but the pieces before us suggest horizontal spreading, the upper sides alone with corallites, whose edges rise for only ·5 to 2 cm. above the general level of the stems. The calices vary up to 4 mm. in diameter, the terminal about half this size.

There is a thick deposition of corallum externally and the central connections of the calices may be largely filled by a similar deposition internally.

The species closely resembles *kauaiensis* in its granular surface and in its coarse longitudinal striæ, these being continuous along the whole under surface. Some of these on the upper surface are associated with septa and are costal, but around each calice the lines are obscured and twisted, in some parts with an almost perforate appearance. The striæ show best on the older and larger parts of the corallum and are often strengthened by transverse bars.

The septa are in three cycles, in larger calices with a few of a fourth cycle. The septal margins are toothed, and the septa are little exsert. Not less than 12 septa are joined by trabeculæ from their inner ends, thus forming a columella the papillæ on which may merge externally with the septal teeth.

Madrepora kauaiensis Vaughan.

Vaughan, U.S. Nat. Mus., Bull. 59, 81, viii, 1, 2, (1907).

The above excellent description applied equally well to our specimens, the sole difference being that our calices are, as a rule, not " solidly filled with stereoplasm ", the cavity persisting as is usually the case in *M. oculata* and *prolifera*. Even in filled-up cavities of *oculata* we find that the position of the original cavity is usually to be recognized by a slight difference in colour and texture of the corallum as compared to the very dense and often thick corallum surrounding the same.

St. 42, 1415 m., r. m., dead ; St. 108, 786 m., gy. m., dead material with some living branches ; St. 122, 732 m., gy. gr. m., as last, the dead coral near the base of colonies with central worm tubes ; St. 124, 914 m., gy. gr. m. s., a fragment growing on a stem formed of elongated sponge spicules ; St. 184, 1270 m., gn. m., dead.

Madrepora investigatoris Alcock.

" Investigator " Rep., 24, iii, 1*a–b* (1898).

Dead material from St. 42, 1415 m., r. m., St. 54, 952 m., 1046 m., gn. m., and St. 184, 1270 m., gn. m., contains coralla of this species. There are also fragments of a species with larger corallites, which cannot be identified.

Growth-variation in *M. prolifera* (Linnæus).

Among deep-sea corals, viz. living below the light zone, Duncan* has already referred to the great variation of this species. The start is a simple polyp, from which a secondary polyp is given off close below its tentacles ; its cavity remains continuous with that of its parent, at least for a long period, but its internal corallum is laid on to that of its parent.

* ' Trans. Zool. Soc.' VIII, 303 (1873).

A third polyp is budded out from the second polyp, but on the opposite side of the stem—and so on ; the result is a zig-zag stem with a polyp standing up at every angle. Externally, the whole corallum is covered by polyp-tissues, which are continuously depositing further corallum on the skeleton below them. Internally there is the small central connection of the polyps along the stem, into which 12 to 24 septa project, its diameter dependent on that of the original bud. This is not immediately reduced by deposition of corallum, being only completely closed towards the bases of heavy colonies. Its septa, however, are joined across by irregularly-arranged trabeculæ, especially towards the centre of the tube. While these may completely close the internal connections of polyps, we have failed in this type of growth to find the horizontal tabulæ of Duncan, which are supposed to act to this end. The corallites rarely possess more than 48 septa, and these are usually rather irregularly arranged, 6 to 12 markedly more exsert. The septa are untoothed, and pali and columella are not found, though the septa may unite in the centre of the calice. The costæ of the larger septa exist until the valleys between them are filled by deposition of corallum.

In a collection of corals of this species the typical growth-form as sketched above may be scarcely recognizable, the mode only visible at the ends of branches. Additional buds may form on the surface half-way down polyps, and from these new stems may grow out, giving rise to a mass of branches which fuse wherever polyp tissues touch. Where there is open water and a firm base of attachment (as in an example from a telegraph cable), the coral grows up for a few inches and then spreads horizontally. Most specimens from the coasts of the North Atlantic show this to some degree, one from Lousy Bank being so extreme as to suggest current influence in addition. On such horizontal growths it is noticeable that there is no absence of polyps in their under-surfaces, their number only showing reduction, which is sometimes compensated for by increased size.

Instead of the terminal polyp giving off a single bud, there may be a pair opposite one another, when two stems will be formed with an axillary polyp between. In place of a pair there may be three or more buds irregularly arranged or perhaps on the same side. As already mentioned, polyps may be budded off from the sides of older polyps, their corallites unconnected with the central cavities of the parent stem, but this is not usual. This phenomenon is best seen in a colony from Portuguese waters, where the polyps are all striving to grow in a single direction, presumably at right angles to the attachment of their colony. The result is a multiplicity of tightly-packed stems, ending in elongated vertically-growing polyps.* The coral stems show little thickening and, in consequence, the costæ of the larger septa may extend for 1 or 2 cm. down the outsides of the branches.† Internally in these elongated corallites dissepiments are more regular and may simulate tabulæ.

In normal colonies there are great differences in the size and massiveness of the stems produced by the external deposition of corallum. The corallites also vary greatly in size, in one colony having an average diameter twice that of another ; usually a few giant corallites of 10 to 12 mm. diameter are found in any large colony. A stem may be so thickened that there are no costæ, and corallites, once standing up freely, may appear sessile. The larger septa may be scarcely exsert at all, but generally 12 septa stand up

* We may deduce that this coral was growing in a hole, or on a very soft bottom, into which its weight was causing sinkage.

† Compare *M. anthrophyllites* E. & S. [Ed. & H., ' Cor.' II, 118].

for 2 to 3 mm. in a characteristic manner. Beyond 24 the number of septa depends on the size and shape, especially the compression, of each individual corallite.

Lastly, there is the association of this coral with *Eunice*. The polyp tissues may grow over and around shells and other foreign objects, with which they come into contact, so as completely to imbed them. This is presumably the case with this worm, but the process is not clear. The final effect is that about half the colonies have hollow stems, in which cavities *Eunice* dwells. It certainly did not bore these, and the association is one requiring study. It is found also in *M. oculata*, particularly abundantly off the coasts of the North Atlantic.

Genus *Madracis* Ed. & H.

We have before us the following specimens from the Indian Ocean. We deem them to be too small and few for identification.

(*a*) " Murray " St. 67, 274 m., sft. gn. m. st., a broken-off branch, dead and much worn, the facies of *M. asperula* Ed. & H.

(*b*) " Murray " St. 111, 73–165 m., ? r., a small incrustation with about 25 tightly-packed calices not exceeding 2 mm. in diameter, 10 large septa and 10 others, calicular appearance recalling *M. kauaiensis* Vaughan (Bull. 59, ' U.S. Nat. Mus.', 83, ix, 1907).

(*c*) " Murray " St. 149, 311–339 m., c. s. sh. cr., a dead colony with branches, resembling *M. hellana* Ed. & H.

(*d*) " Maldive " Expedition, Kolumadulu 2, 30–35 fms., a small encrusting mass and an upstanding pillar, resembling the Mediterranean species *M. pharensis* Döderlein (' Mitt. Zool. Sta. Neapel,' XXI, 183, 1913).

(*e*) " Sealark " Expedition, off Salomon Atoll, Chagos, 60–120 fms., a small incrusting mass, which may belong to *M. decactis* Lyman (' Proc. Boston Soc. Nat. Hist.', VI, 1867, and Pourtalès, ' Cat. Mus. Comp. Zool.', IV, 28, 1871).

Genus *Parasmilia* Ed. & H.

Parasmilia fecunda Pourtalès.

Cœlosmilia fecunda Pourtalès, Cat. Mus. Comp. Zool. IV, 21, p. 6, i, 12 ; iii, 4, 5, ; vi, 14, 15 (1871).
Parasmilia fecunda Lindström, Kongl. Svensk. Akad., 21 (1877) ; Marenzeller, " Valdivia " Exp., 311, xv, 5 (1904) ; Gravier, Comp. Sci., Monaco, LV, 91, xi, 169–73 (1920).

St. 209, 366 m., gr. br. m. r.

Five specimens belong to this species, which Marenzeller obtained off Sumatra, 380 m., previous records being from the West Indies and Atlantic. The cycles of septa are very distinct in thickness and there is a marked tendency, best seen in sections, for the septa of the latest cycle to converge on that which precedes it. Our specimens agree closely with those which Pourtalès described.

Genus *Solenosmilia* Duncan.

Solenosmilia variabilis Duncan.

Duncan, Trans. Zool. Soc. VIII, 327, xlii (1871) ; Moseley, " Challenger " Rep., 181, ix, 1–5 (1881) Gardiner, Trans. Roy. Soc., Edin. XLIX, 689 (1913).

St. 209, 366 m., gr. br. m. r.

There are 21 stems of this species, all dead but little decayed. They are all thickened

by extrathecal deposition of corallum, and this has presumably covered the costæ, except close under the calices, so that the stems are quite smooth.

The Scottish National Antarctic Expedition obtained this species in lat 37° 56′ N., long. 29° 11′ W. It seems to be generally distributed over the Atlantic into the Antarctic down to 1000 fms. Now its range is extended into the Indian Ocean. I have also a series, sent to me by the late Prof. Gilchrist, from off Natal ; they are quite indistinguishable from the present forms. *S. jeffreyi* Alcock may be identical, an " immense mass " from 434 fms., with larger calices, diagnosed by us as having existed in the happiest environment.

Genus *Culicia* Dana.

Cylicia Ed. & H., Cor. II, 606 (1857).

We have before us specimens which superficially might be assigned to five species ; they were collected in the Red Sea, Indian and Pacific Oceans. All the calices have the epitheca as their wall and a creeping, low growth. Their differences lie in variations of septa, pali and columella-rods and also to a certain degree in size and depths of calices, all of which characters show a wide range. The difficulty is to identify them with described species, for the range of variation of no species has been accurately determined.

Culicia tenella (Dana).

Dana, Zooph., 377, xxviii, 6 (1846).

St. 89, 135–183 m., s. sh. r., 2 small colonies ; St. 123, 256–366 m., gn. m. s. r., 2 small pieces.

These agree with the description above, but few corallites are undistorted, having been killed around their edges by the growth of other organisms. There tend to be present a few septa of cycle IV, but the cycles are not generally clear. The species appears to us to range from low tide to the above depth.

Genus *Fungia*.

The following material does not admit of specific identification. It is all of the *patella*-type, which was reconsidered in a special " Siboga " Expedition Report in 1923 by Dr. Boschma.

St. 103, 101 m., c. s. sp., 1 piece *Diaseris*-form, dead ; St. 106, 183–194 m., gr. m., 2 dead ; St. 126, 209 m., lt. br. m. sp., 2 whole and 2 pieces, 1 with open scar of attachment, recently dead ; St. 141, 44 m., c. s. sh. cr., 15 pieces *Diaseris*-form, dead, 10 *Cyclo-seris*-form, mostly dead and young ; St. 144, 31 m., c. sh. s., 1 living and 2 dead ; St. 154, 457 m., 3 pieces *Diaseris*-form, dead ; St. 161, 46 m., c. s., 5 tiny specimens, mostly living.

Genus *Bathyactis* Moseley.

Bathyactis symmetrica (Pourtalès).

Fungia symmetrica Pourtalès, Cat. Mus. Comp. Zool. IV, 46, vii, 5, 6, (1871).
Bathyactis symmetrica Moseley, " Challenger " Rep., 186, xi, 1–13 (1881).

St. 185, 2000 m., gn. m., 7 flat discs with all parts thin and fragile ; they measure 28, 33, 15, 14, 12, 10 and 9 mm. across. Their lower sides have 12 costæ more prominent, radiating from a slightly upstanding, central point ; otherwise the plicate arrangement

is as described by Moseley. The largest specimen shows quinary septa in the only unbroken piece of its margin. The columella part is filled by twisted and anastomosing trabeculæ from septa I and II.

St. 176, 655–732 m., gn. m. s., part of a disc regenerating ; St. 54, 1046 m., gr. m., a disc of 5 mm.

Bathyactis (*?*) *symmetrica* (Pourtalès).

St. 59, 1948 m., sft. gn. m. A single dead specimen, 8 mm. diameter, characterized by a firmer skeleton and regular margin ; costæ in centre less marked owing to a secondary

Fig. 1.—*Bathyactis stabilis* n. sp. Upper surface. × 10.

deposition of corallum ; septa very regular, not nearly so high as in normal specimens of *symmetrica* of the same size ; synapticulæ abundant but not in regular concentric circles ; no pali and a rather solid junction of septa I and II in centre. These appearances may be due in part to a secondary deposition of lime after death.

Bathyactis stabilis n. sp. (Text-figs. 1 and 2.)

St. 118, 1789 m., gl. oz., a single specimen, 10 mm. across, one sector broken when obtained and regenerating.

Completely discoidal, with a rather firm skeleton. Basal wall flat, marked by 12 distinct costæ and 12 smaller intermediates, all reaching a prominent point in the centre, with 24 others alternating with these and not reaching the centre.

Septa, 4 complete cycles, 6 primaries free and the rest showing the typical, generic, deltoid characters. Septa all relatively low, straight (not wavy), toothed. Synapticulæ

very scarce, no circular arrangement, innermost about the level of the junction of septa IV to III.

Septa I and II slope down to the centre of the corallum, giving rise to a broad central columella-like fusion, on which arises a small central style with a ring of 12 similar rods around, as if derived from teeth on the inner ends of the larger septa, the whole rather irregular (*vide* Fig. 1).

This species closely resembles Moseley's pl. xi, fig. 10, of *Bathyactis symmetrica* ; this clearly is not a growth stage and may be our *Bathyactis stabilis*.

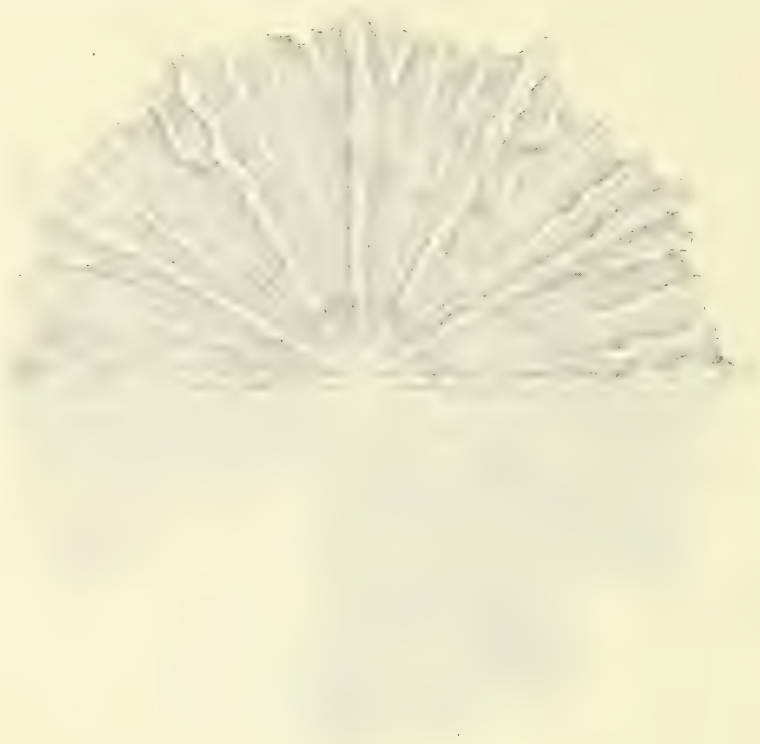

Fig. 2.—*Bathyactis stabilis* n. sp. Lower surface. × 10.

Bathyactis stephana Alcock.

"Investigator" Rep., 28, iii, 5 (1902).

A single specimen 34 mm. from off Natal belongs here. It was sent by the late Prof. Gilchrist and shows clearly the characters described by Alcock.

Genus *Pachyseris* Ed. & H.

Two dead fragments from St. 125, 805 m., lt. br. m. over gy. cl., are not specifically identifiable.

Genus *Psammocora* (Dana).

Gardiner, Proc. Zool. Soc., 1898, 533, and Fauna Geogr. Maldives and Laccadives, 950 (1906).

We experience the same difficulties in respect to this genus as one of us felt forty-one years ago, but, even after this lapse of time, there are few additonal study specimens in our

Museums. Accordingly, we leave the question of the genus, as it would be impertinent to reconsider views on the study of a series of a single species such as follows. The importance of the collector recording not merely the locality and depth, but also such features in the local environment as current flow or protection from same, wave effect, turbidity of water, crowding by other organisms, free-living on rocky, muddy or sandy bottoms, etc., is very clear.

Here, having knowledge of some of these features, we believe that the specimens below enjoyed a somewhat placid existence on a rather smooth bottom, largely free from sand, whereas the type-forms of the species lived on the surface of a lagoon shoal, were subject to changes of temperature, harassed by waves and swept by currents, while on every side other corals, alcyonaceans and algæ, like *Halimeda*, were struggling for their sites.

Psammocora superficialis Gardiner.

Proc. Zool. Soc., 1898, 537, xlv, 2 ; Yabe, Sugiyama and Eguchi, Sci. Rep. Tôhoku Univ., 1936, xli, 4, 5.

There are upwards of 50 specimens which came from St. 45 in the Gulf of Aden, 38 m. deep. " The dredging was a relatively rich one, containing some Alcyonaria, several sponges, etc., also much *Lithothamnion*, some free some attached." The area seems to have been " one of an essentially calcareous-secreting fauna ", the only other corals being a few small *Caryophyllia*. The bottom was " a very smooth one " in spite of the above, certainly neither crowded nor subject to a strong rush of waters.

The coralla are mostly rather flat and spreading, their edges thin, with an imperforate wall below and marked by thin " costal " ridges. A common size is 3–5 cm. across, the whole more or less rounded. The polyp larvæ would appear to have settled on some hard object, budded off polyps and grown out horizontally on all sides, the resulting coralla being slightly domed, as the corallum is formed evenly and continuously below the polyp-layer. Then worms and other boring forms entered the thickened corallum, riddling it underneath with their tubes and giving this part a decayed appearance, the unaltered corallum above seldom more than 10 mm. thick. The slightly lower, surrounding edges of the coralla tend to be killed, but the polyps within usually compensated by growing out new edges at a higher level* ; in consequence the domed growth is less apparent.

Meantime, with the decay below the centre, much of the dead corallum disappears and there results a series of rounded, rather flattened coralla lying freely upon the bottom, their surfaces covered completely by polyps. There is no arrangement of calices with collines between, the whole being smooth and regular.

The calices in surface view average almost 3 mm. across and are shown admirably in Yabe's fig. 5. Superficially the living surface of a corallum may be nearly level, the centres of the calices indicated by tiny pits. More often the calices are 5-sided, shallow areas, marked off by low walls. Relatively even-sided, thick septa with narrow inter-septal spaces cross these, their edges capped by even-sized, transversely-arranged, coarse granules. In young calices there are frequently 6 septa reaching to the columella-space, but in older this number is often more than doubled. It is all a question of filling such

* Such killing might be occasioned by sand or mud, by growths of surrounding organisms or even by rocking on a relatively hard bottom. Growths of Polyzoa, hydroids, worms, *Polytrema*, etc., are found on the undersurfaces, but, by analogy with other species, we are inclined to suggest the last killing agency above.

spaces as become available in the growing calice with septa which must be of approximately similar thickness and structure. Thus, great irregularity prevails in the septal arrangement, as buds may form anywhere over the septa, and the latter always become joined to those of neighbouring calices. A false appearance of branching septa is given when the septa are traced between calicular centres, but the primary septa often run from centre to centre unbranched or branched only on one side.

The axial (columellar) space is quite distinct, but seldom more than 3 mm. across. It may have in the centre a single upstanding rod, or 3 or 4 rods irregularly arranged, or a central pillar with 6 rods around, these simulating pali.

Transverse sections of the coralla show nothing more than can be seen in surface view. In longitudinal sections relatively thick walls can be recognized between the calices and joining the connecting septa; septa and walls tend to be solid below, becoming more perforate towards the surface of the corallum. The centre of each calice is filled-in by relatively thick trabeculæ from the septal edges, and there are no true columellar rods down the same. In addition there exist across the spaces between the septa the thinnest possible dissepiments, but there is no regularity in the distances apart of these. They seem to run to and across the central part and so must form the limiting factor in the depth of the polyp-covering.

Genus *Stephanophyllia* Michelin.

We have specimens before us of all the three species below from off Natal and of *St. complicata* from Saya de Malha, 125–145 fms. These specimens are such as to suggest to us that all three are good species, no undue overlapping. The genus has a wide range into the waters of the Phillipines and Japan. Yabe and Eguchi* refer to 5 living and 11 fossil species from the Upper Cretaceous or later. Of the living species *St. fungulus* below occurs in the Pliocene of Japan. Van der Horst shows that *St. superstes* Ortmann is a synonym of *complicata*.† The fifth species is *S. neglecta* Boschma from "Siboga" Expedition (p. 16, 1923).

Stephanophyllia formosissima Moseley.

"Challenger" Rep., 201, iv, xiii, xvi, (1881).

St. 113, 253 m., s. m. pt., 1 recently dead, 13 mm. diameter.

Stephanophyllia complicata Moseley.

"Challenger" Rep., 198, iv, xiii (1881).

St. 153, 256 m., 3 of 19, 17 and 15 mm. diameter.

Stephanophyllia fungulus Alcock.

"Siboga" Exp., 40, v, 35 (1902); Tijd. Ned. Dier. Ver. (2) VII, 3 (1902).

St. 149, 236 m., cr. r. lth., 1 of 9 mm. diameter.

* 'Sci. Rep. Tôhoku Univ., Geol.' XV, 55–63, viii and ix (1932).

† 'Trans. Linn. Soc.' XIX, 51 (1926) and Ortmann, 'Zool. Jahr. Abt. Syst.' III (1888).

The specimen fits Alcock's description in every respect except that the columella is more diffuse and a little larger. The teeth on the septa are thick, tranverse extensions across the upper edges of the relatively thick septa and give an appearance of broken concentric circles when the upper surface of the disc is examined.

Genus *Dendrophyllia* (de Blainville) Ed. & H.

In our identifications of the species below we have largely followed van der Horst, " Siboga " Rep., 48–58 (1922), ' Trans. Linn. Soc.' XIX, 43–48 (1926) and ' Fish Mar. Survey, S. Africa,' V (1927). We have before us the specimens considered in the last two of these reports, and of *D. japonica* Rehberg from the ' " Terra Nova " Report ', 127 (1929). We also have co-types of Pourtalès' species. An examination of the specimens in the British Museum not having proved at all helpful in a critical direction, our determinations below may be regarded as following the lines of van der Horst to the extent of almost forming a sequel to his three Reports. We agree with him as to the difficulty of separating young forms of *Dendrophyllia* with single calices from *Balanophyllia*, his phrase being " practically impossible ". Furthermore, the latter genus introduces a complication in that young coralla tend to settle on the sides of older and form masses, such anomalies as those referred to by us in *Paracyathus conceptus* (' " Murray " Exp.', 181–186, 1938).

In the present position of the taxonomy of the genus, there are more than 45 living " species ". Of these, we prophesy, that only a fraction will be preserved when the genus is revised by some experienced specialist who has the means to visit the types and who has large collections at his disposal. Even the most upright growing species may become almost a ground mass, its branches fusing together—the polyps share in this fusion—and its calices reduced in size. An example of this is *D. micranthus* (Ehrb.), the most abundant, coral-reef species down at 20 fathoms and deeper; of this, branches of more than a foot long are common, themselves freely branching.*

Dendrophyllia robusta (Bourne).

Lobopsammia robusta Bourne, Trans. Roy. Soc., Suppl., XIX, 212, ii, 10 (1905).
Dendrophyllia coccinea van der Horst, " Siboga " Rep., 55, viii, 21 (1922).
Dendrophyllia klunzingeri van der Horst, Trans. Linn. Soc. XIX, 46 (1926).

St. 45, 38 m., lith., 2 specimens with 14 and 9 calices.

One of us (J. S. G.) had occasion to examine and discuss the type specimen of this species with Bourne, finding himself in disagreement, for he considered that there was no justification for the view that the colony was formed by fissiparity, as indeed is confirmed by Bourne's fig. 10; in this van der Horst agrees. Our largest calice measures 17 by 13 mm., but the average larger calice is about 13 by 10 mm.

Dendrophyllia axifuga Ed. & H. (Text-fig. 3.)

Ann. Sci. Nat., ser. 2, X, 101; Cor. III, 119 (1860).
Van der Horst, " Siboga " Exp., 53, vii, 1 (1922).
Duncanopsammia axifuga Wells, Ann. Mag. Nat. Hist., ser. 10, XVIII, 546 (1936).

We mention here a remarkable specimen lent to us by Dr. Stelfox out of the National Museum of Ireland. It is recorded as coming from Australia and it grew on a clear-lip

* *Vide* van der Horst, ' Trans. Linn. Soc.' XIX, 43 (1926).

pearl shell of 19 cm. diameter. It has a central stem about 7·5 cm. across and from this radiate 12 horizontal branches at a level of 5 to 6 cm. above the shell, each 7 to 9 cm. long and usually dichotomously branching so as to fill all available space. These have polyps only on their upper surfaces and budding takes place at the edge of the terminal calices of the branches. In addition there are two branches standing up vertically over the central mass for 4 to 5 cm. and then bending to spread horizontally.

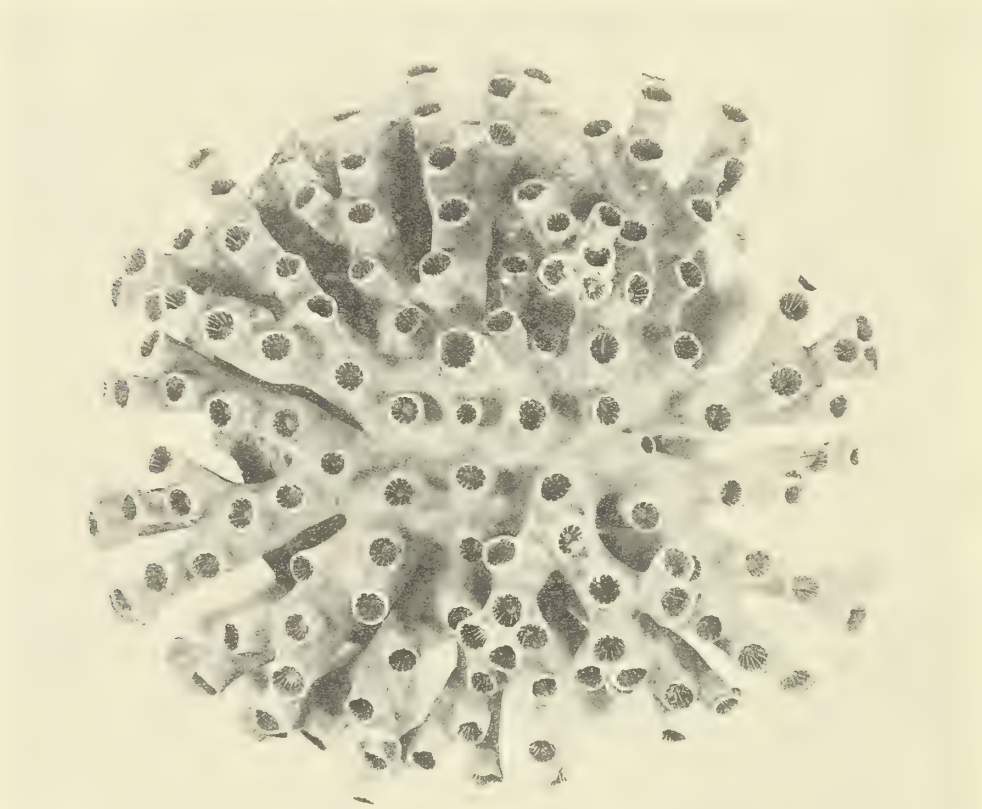

Fig. 3.—*Dendrophyllia axifuga* Ed. & H. × $\frac{2}{5}$. Attached to the outer surface of a pearl shell of 19 cm. diameter.

The specimen displays the natural form of growth of the coral where it is raised above the bottom and uncrowded—and its interest is thus mainly ecological.

Dendrophyllia coccinea (Ehrb.).

Dendrophyllia ehrenbergiana van der Horst, " Siboga " Exp., 55, vii, 3, 4.
Dendrophyllia coccinea van der Horst, Trans. Linn. Soc. XIX, 45, iii, 1–3 (1926).

St. 112, 113 m., cr. r., a specimen 6 cm. high with 3 calices.

St. 157, 229 m., cr. r., a single calice 2·5 cm. high and 2 calices 2 cm. high. This dredging is also remarkable for the large amount of dead coral it contained, all of allied genera. In this could be recognized the above species as well as *D. fistula* Alc., *D. horsti* n. sp. and *Balanophyllia diffusa* H. & P.; it included no imperforate corals.

Dendrophyllia minuscula Bourne.

Trans. Phil. Soc., Suppl., 213, ii, 11 (1905).

St. 157, 229 m., cr. r., the two specimens below.

A branch, 4·5 cm. long with one twig, has 17 calices arranged alternately on either side of its stems. The whole surface is finely granulated and costæ are only visible close below the calices. The colony originally attached itself to a dead *Caryophyllia*, which its base has overgrown.

A bifurcated terminal twig with 7 calices, which were budded-off alternately but now have twisted to one side of its stem, causing the calices to be rather oval and little raised ; it has equal-sized costæ along its whole length.

Dendrophyllia fistula (Alcock).

Balanophyllia fistula Alcock, " Siboga " Exp., 42, v, 36 (1902).
Thecopsammia fistula Marenzeller, " Pola " Exp., 4, i (1906).

St. 106, 183–194 m., gn. m., a single bent calice arising from a broad base, about 3 cm. high, dead.

St. 157, 229 m., cr. r., about 40 branches varying up to 40 cm. long.

The branches are usually dead below but have 1, 2 or a little group of living calices, the side ones arising at 80° to 90°, generally within 10 cm. of a terminal calice. Some of these appear to be secondarily attached forms, their bases extending round a main stem, but in most there is a continuity in the run of costæ which precludes this idea. The 6 primary septa, with the septa on either side fusing to the same, form 6 groups markedly more exsert and upstanding on the theca. There are 4 cycles of septa, IV fusing to III before the latter runs into the rather large, oval columella, often slightly swollen laterally in the centre and formed of packed ribbons.

Some of our specimens are thicker, more branched and with a less naked appearance than von Marenzeller's figures, and nearly all stems up to about 1 cm. below any living calices are dead, with signs of decay. Two young, recently formed coralla have their calices rather cornute and one of these has signs of an imperfect epitheca.

St. 209, 366 m., gr. tr. m. r., a number of dead fragments.

Dendrophyllia horsti n. sp. (Pl. II, figs. 5, 6.)

St. 157, 229 m., cr. r., about 12 specimens.

There are 8 colonies before us, each having 3 to 5 calices and most show a broad base of former attachment and a very dense corallum. The costæ are usually equal and visible from the base along the stems, but are relatively little marked save near the calices. The septa are rather irregular, 4 cycles, over the theca septa I with its neighbouring pair of IV joined and forming exsert groups. The pairs of IV on either side of III join internally to the ends of same and then run into the columella, which only deep down in the calices is joined by I and II ; in consequence III are the narrowest septa in the calice. The columella is a densely-packed, oval mass of ribbons upstanding in the centre of the calice.

The calices vary up to 10 mm. in diameter, very slightly longer than broad. No colony is more than 5 cm. high. All budding is near the calicular margin.

The species bears resemblances in the detail of its calices to *D. arbuscula* van der Horst, ' " Siboga " Exp.' 53, viii, 6 (1922), but his photograph of this species is one of a colony that would be expected to form arborescent growths of some height, whereas our specimens here suggest genetically dwarf, massive, little colonies, never forming high stems or growing vigorously. They tend to be dead at the base and some are bored into by worms.

Dendrophyllia ampheloides Alcock.

" Siboga " Exp., 43, v, 37 (1903).

St. 149, 311–339 m., c. s. sh. cr., a number of dead pieces, which apparently belong to this species, of which Dr. Boschma has supplied us with a good specimen from the Kei Islands, 385 m.

Genus *Balanophyllia* Ed. & H.

We understand the genus as defined by van der Horst.* It is characterized by the coalescence of the septa of higher cycles to form chevrons before running into the columella, which is present in all species. The same remarks apply as to *Dendrophyllia* above and there are about the same number of living " species ".

Balanophyllia cumingii Ed. & H. (Pl. I, fig. 1.)

Ann. Sci. Nat., ser. 3, X, 87 (1847) and Cor. III, 104 (1860).
Bourne, Trans. Roy. Soc., Suppl., 1905, 209, ii, 7, 7*a*.

In 1888 the Cambridge Museum received 16 corals from lat. 6° 01′ N., long 81° 16′ E., 34 fms., which is S.S.E. of Ceylon. All these are horn-shaped, and the larger were lying unattached on the bottom. The longest around the curved side is about 4·5 cm. high, calice 20 by 14 mm., and the rest are rather evenly distributed in size down to 1 cm., 7 by 6 mm. The edge-zone of the polyp overlaps to two-thirds of the height of the corallum, in some of the specimens completely covering the calice. There is no true epitheca, but there may be a certain deposition of lime below the lower limit of the edge-zone, which simulates an epitheca. The costæ and the lines of perforations in the narrow valleys between are distinct. Twelve septa in the larger specimens stand up conspicuously over the theca, but there is great variation here ; they have, near the theca, the neighbouring septa fused to them. Ed. & H. and Bourne are both correct for the size of the specimens, and Bourne's figure (7*a*) is admirable. The columella is deeply situated, and the edges of the large 12 septa fall vertically to the same.

In smaller specimens septa I run straight to the columella. Septa II are thinner and extend in at a lower level after having a pair of III fused to its sides ; each of the III has similarly 1 or 2 septa of IV joining it. With growth septa II assert themselves more definitely, but there is nearly always a bending of III towards them, though the latter may join direct to the columella, which all the time has been increasing in size and consolidation. Finally, septa V are formed and attach themselves to IV, 38 out of 48 being present in one large calice. Variations occur in that septa may fail to reach the cycle

* ' " Siboga " Exp.' 48 (1922).

to which their edges should fuse. One specimen is a calice regenerated from the broken-off part of the wall of a larger corallite, this including 2 septa of I.

This species bears close resemblances to *B. bairdiana* Moseley, of which the British Museum specimens are before us. They are all very markedly compressed. Septa I and II stand up less conspicuously above the theca and join the columella at a lower level in the calice than the intermediate fused septa. The septal arrangements are admirably shown by Moseley, and there is very little variation in the 5 specimens before us, 2 Moseley's* types and 3 Australian Museum from a single locality.

Balanophyllia diffusa (Harrison & Poole). (Pl. I, fig. 3 ; Pl. II, fig. 4.)

Proc. Zool. Soc., 1909, 906, lxxxv, 4.

St. 112, 113 m., cr. r., 31 calices, mostly attached to dead coralla of the same, usually close to old calicular margins, but with 10 living calices suggesting budding before the death of the original calice.

St. 149, 311–339 m., c. s. sh. cr., a dead and partially decayed corallite of large size.

St. 209, 366 m., gr. br. m. r., a large, broken-off, rather compressed, dead corallite.

St. 157, 229 m., cr. r., 16 living calices, as many partially dead, some with still living " buds ", and a quantity of dead and partially decayed material, the character of " budding " well shown.

Here over 60 calices of firm texture, which vary up to 77 mm. in diameter and are attached by strong stems, the diameter of which may average about half of that of the calice. Much or indeed all may be covered by the edge-zone, but there is no trace of epithecal formation. Usually round the edge of the calice and over the theca are 12 upstanding parts, centred in septa I and II, but sometimes these are not visible. The septal and costal arrangement are as described and figured by the authoresses above, but in odd specimens costæ scarcely show and septa V are more distinguished by their absence than presence ; the septal junctions of IV to the rather lower inner ends of III are more regular than shown in their figure. The calicular fossa is said to be shallow, but this depends entirely on whether the calice has assumed a spreading growth or not ; we should describe the average depth as about half the breadth of the calice. Deep specimens may show the edges of the septa falling almost perpendicularly to where they join the columella. The conjoined septa III and IV in one specimen show this part almost like a tooth ; in others there is a slight, transverse broadening and thickening as they pass to the columella, while the " encroachment " of the trabeculæ of the latter may be found in odd systems of any specimen and is not a specific character. The columella is always well developed, but varies very greatly in breadth with the depth of the calice ; its surface may be flat or an upstanding dome. In young forms it is built of very fine anastomosing trabeculæ, but these, with increase in size of the calices, become coarser, and so fused-up that in an extreme case it might be described as an elongated solid mass of corallum joined by septa I, II and III–IV along the centre of the axial fossa.

It appears to us that the type specimens fall within the limits of variation of our collection in spite of the depth of 3–20 fms. whence they came. Our series of forms taken

* ' " Challenger " Rep.', 191, text-fig. and xii, 4, 5 (1885). We have not found the specimen represented in figs. 6 and 7 of pl. xii.

together suggest that a polyp grows up on some solid base, attains average size, then buds off one or more polyps close to the edge of its calice and dies of " senile decay ". The young polyps then repeat the same process, and the dead and living conjoined produce pseudo-colonial formations.

Balanophyllia cornu Moseley.

" Challenger " Rep., 192, text-fig. and xii, 11–15 (1885).

St. 157, 229 m., cr. r., two very markedly cornute specimens, one with a small form attached, measuring 20, 16 and 10 mm. along the calicular mouth. As there are a large number of specimens in the " Discovery " collections further comment is reserved for the report on the same.

Balanophyllia diomedeæ Vaughan.

U.S. Nat. Mus., Bull. 59, 152, xlv, 3–5 (1907).

St. 157, 229 m., cr. r., one example, straight, top 10 mm. alive, 37 mm. long, calice 10 by 8 mm. The chevrons are well marked, and the columella showing the same character as in Vaughan's three specimens, one which also occurs in *Dendrophyllia horsti* n. sp.

Balanophyllia affinis (Semper).

Van der Horst, " Siboga " Exp., 62 (1922), and Trans. Linn. Soc. XIX, 48 (1926).

St. 141, 44 m., c. s. sh. cr., 7 living and 2 dead ; St. 146, 37 m., 4 living (small) and 6 dead.

Balanophyllia serpentina Vaughan. (Pl. I, fig. 2, below.)

U.S. Nat. Mus., Bull. 59, 155, xlvi, 2 and 3 (1907).

St. 43, 83–100 m., a large corallite, 28 mm. high, 10 by 8 mm. calice with, half way down, a large bud 12 mm. outstanding, and lower still a smaller with calice 3 mm., pushing through a mass of worm tubes and *Polytrema*, nearly all covered by living tissue.

St. 152, 609–915 m., gn. s., 3 living specimens, single corallites measuring 26, 19 (stem broken) and 23 mm. high, calices 10 by 8, 15 by 10·5, 11 by 8 mm. in diameter.

The specimens agree in all respects with Vaughan's description save that there are no secondary corallites on those from St. 152 ; we observe in Vaughan's figures that these are situated (one being doubtful) below the polyp's edge-zone and hence on the dead stems. The texture of the corallum is much lighter than in any other species we have seen, and the thecal wall in places looks like a network of trabeculæ. While there are no true costæ, there may be ridges extending down for a few mm. in correspondence with the larger septa. Odd septa of V are found only in the largest calice.

Balanophyllia præcipua n. sp. (Pl. I, fig. 2, above.)

St. 111, 73–165 m., ? r., three specimens : (*a*) 17 mm. long, greatest diameter 3 mm., terminal and 3 smaller side calices, standing out nearly at right angles ; (*b*) stem 14 mm. (broken end) with 2 calices at right angle, 6 and 10 mm. long, last carrying a short, smaller

calice, diameter 2·5 mm. ; (*c*) stem 23 mm. long with a calice at each end and a smaller at right angles, diameter 3 mm. Total 10 calices.

Shape as described above, only perforate near calice. Wall granular ; costæ corresponding to 12 septa, thin ridges for most of the length of the coralla. Septa relatively thick and rough ; 6 primary, scarcely exsert, extending straight into the columella, often at a lower level than the next. Six septa II each joined by 2 septa of III rather near their columella end and then extending as broad bands into the same. Septa IV only present in a very few systems of the largest calices thus : a pair quite free on either side of septum II ; a similar pair bent outwards from the same and fused to septa of III ; and in one system a free septum interpolated between III and IV. Columella a rather deep trabecular mass with an appearance as if formed by the continuations of the fused chevrons of II and III.

In (*b*) above the structure of the broken end is so perfect as to suggest that polyp-tissues were present here between all the septa. In (*c*) the small end has 6 systems of septa, each consisting of a primary, a secondary and 2 tertiary, the last three forming a chevron, and the large end agrees, while the bud (diameter 1·5 mm.) has one system irregular. This presence of a polyp at each end of the stem recalls the analogous case of *Stenocyathus* Pourtalès.* We presume that in each case the stem has broken and the contained tissues have regenerated polyps.

The species has no close ally. Its form of growth causes us to think of the quite large *Dendrophyllia cornucopia* Pourtalès,† but it is impossible that it can be a young form of any known *Dendrophyllia*.

Genus *Rhizopsammia*.

Rhizopsammia (*?*) *minuta* van der Horst.

" Siboga " Exp., 65, vii, 9 and 10 (1922).

St. 112, 113 m., cr. r., 1 specimen with 3 calices, two of which have just separated from one another, apparently by division of a polyp.

Genus *Endopachys* (Lonsdale).

Endopachys grayi Ed. & H.

St. 90, 91 m., s. sh. cr., a single medium-sized specimen, showing scar of former adherence.

Genus *Heteropsammia* Ed. & H.

The two species below are the same as those so identified by van der Horst from the " Siboga " and " Sealark " Expeditions (' " Siboga " Exp.', 66, 1922, and ' Trans. Linn. Soc.' XIX, 51, 1926) with some of which they have been compared. The species appear to live down to 200 m., with a preference for depths less than half this.

Heteropsammia michelini Ed. & H.

St. 106, 183–194 m., gn. m., several dead specimens, many showing 2 calices.

* ' Cat. Mus. Comp. Zool.' 9 (1871) ; also ' John Murray Exp.', 172 (1938).

† ' Cat. Mus. Comp. Zool.' 45, v, 7 and 8 (1871).

Heteropsammia cochlea Spengler.

St. 72, 75 m., c. s. sh., 3 of 9, 10 and 13 mm., diameter.

St. 80, 16–22 m., c. s. sh., 7 of 6 to 12 mm., dead and worn specimens.

The exsert ends of the larger 12 septa are only conspicuous in 2 specimens of St. 80. The rest present a rather flattened appearance, which perhaps a little emphasizes the oval shape of their calices, suggesting to us that *ovalis** and *cochlea* are identical.

Genus *Goniopora.*

Goniopora stokesi Ed. & H.

Ed. & H., Cor., III, 192 (1860).

Goniopora Maldives (4) 4, Bernard, Brit. Mus. Cat., 76 and 89, vii, 6, and xiii, 9 (1903), identified in text as above.

St. 147, 27 m., sft. cm. m., Horsburgh (Goifurfehendu) Atoll, Maldives.

There are 11 corals, the largest being 29 mm. across ; it is the shape of a half sphere and has on the domed surface about 40 calices with new buds near the spreading edge and, when required above, on the corners where 3 or more calices meet. The middle of the underside is bare and in nowise decayed, the edges to a maximum breadth of 7 mm. are covered with a thin sheet of corallum, quite imperforate, the " epitheca ".

The next-sized corallum is 22 mm. in diameter and 9 others give a succession in size down to 8 mm. with 9 calices. None of these specimens show any traces of " epitheca ", their lower sides built of fused trabeculæ, quite sponge-like in texture.

Bernard described his older Maldivan specimens, chosen out of a long series dredged by one of us, as " built up of successive, hemispherical almost columnar, caps fitting imperfectly into one another ". The description is inapt, for the central part, perhaps inches thick, has no epithecal plates one over another, but is a mass of trabeculæ as described above ; some small specimens collected with these have the structure of the 10 small forms. Bernard (p. 90) regarded his Maldivan forms as " probably a well-marked genetic group ", in other words *G. stokesi.*

Clearly there is no true " epitheca ", based on a " primitive epithecal cup " as Bernard expressed it (p. 18), but a later secondary formation. Remembering that these corals are free and unattached, the advantage of a plate of corallum under the edge is obvious, but the desirability of a complete epithecal covering below the young corals, thus protecting their polyp tissues from the comparatively muddy bottom which the species affects would seem to us to be much greater.

Goniopora lagreneii (Ed. & H.).

Rhodaræa (?) lagreneii Ed. & H., Cor. III, 184 (1860).

Goniopora, China Sea (5) 5, Brit. Mus. Cat. Madreporaria, IV, 73, v, 7 and 8, xii, 11 (1903).

St. 27, 37–91 m., s. sh., two ends of branches.

Bernard's corals were from 32, 40 and 42 fms., and our specimens closely agree in all respects. He also assigns to the same with doubt some coralla from the Macclesfield Bank, 40 fms.

* Semper, ' Zeit. Wiss. Zool.' XXII, 266 (1872).

B. THE ECOLOGY OF SOLITARY CORALS

BY

J. STANLEY GARDINER. M.A., F.R.S.

The Formation of the Skeleton—The Characters of Polyps—The Function of the Skeleton and its Use in Taxonomy—The Variation in Skeletal Characters—Discoid Coralla—Cycles of Septa, Pali and Columella—Use of same in Taxonomy—Importance of Growth Stages—Correlations with Environments—Freshwater—Temperature—Water Movements—Rocky and other Bottoms—Free-living Corals—Pressure—Light in Shallow Waters—Colour—Living and Fossil Corals.

The classification of the Madreporaria can only be regarded as in a profoundly unsatisfactory state. In the first place they have a skeleton of carbonate of calcium, the mode of formation of which we do not know, some workers regarding it as lying completely outside the ectoderm and others as formed within the tissues of the polyp.* All that can be said at present is that it is not derived from that of the Alcyonaria, which is essentially spicular, this sub-phylum not having come into existence before the middle tertiary period, whereas the Madreporaria are pre-Cretaceous. Any phylogenetic relationship to the Tetracoralla is admittedly speculative. However, the natural expectation, in all these groups and in the Hydrocorallinæ, would point to similar physiological processes forming the skeleton in all three. It must be emphasized that it is calcium carbonate with a small trace (less than ·2 %) of magnesium carbonate, while in the salts of seawater more than three parts of magnesium are present as compared with one part of calcium. This is in marked contrast to the lime skeleton of algæ, which is formed intracellularly and contains magnesium in large quantity, estimated as carbonate up to 25%.

Many of the families of Madreporaria are ill-defined, genera being bandied about between them by Milne-Edwards and Haime, Duncan and the more compelling of the later taxonomists. They are hopeless, partially because the worker has usually studied only living or only fossil forms, and in neither case has thought about their polyps. There have been described about 1000 genera, of which less than 400 have been substantiated. Of the solitary corals, the earliest in evolution, more than half the genera are fossil.

The basal element is the species and there are few essential functions in solitary corals that must be represented by anatomical characters. No forms have organs of movement or "mouth parts", the more important functions being concerned with carnivorous

* *Cf.* Matthai, 'Proc. Camb. Phil Soc.' XIX, 160 (1918), which contains references up to his date.

Prof. Matthai in a subsequent paper, "Our Reactions to Stimuli in Corals", gave an excellent account of feeding, his observations in 1915 covering 23 species ('Proc. Camb. Phil. Soc.' XIX, 164, 1918).

Prof. C. M. Yonge, whose brilliant series of papers on the physiological processes of coral polyps is well-known ('Gt. Barrier Reef Reports,' I), in a letter remarks: "Skeleton formation is one of the crucial facts in the evolution and success of the Madreporaria and, it seems to me, is *the* great problem in this group, which remains to be tackled."

feeding, reproduction, sensitivity and protection. In the mechanics of most of these there can be little play to produce a great variety of anatomical characters. Tentacles occur over all septa, but they are not always existent; however, in all solitary corals which we have seen in the flesh they seem to be present. They are introvertible, but sometimes there is a sphincter contractility external to the tentacles, which helps the drawing-in of the oral disc. They are set with nematocysts, sometimes evenly distributed, but more often massed in batteries, either large and terminal, or small and scattered. A second class of nematocyst is found in the mesenteral filaments and stomodæum. Cilia may be present all over the ectoderm, except immediately over the corallum, but are concentrated on the oral disc, stomodæum and mesenterial filaments; their uses, viz. to carry off detritus dangerous to the polyps and to produce food-currents, do not lead to varied anatomical characters. Reproductive organs are situated in the middle lamina* (mesoglœa) of mesenteries and may be male, female or hermaphrodite (usually protandrous) and their products are shed into the cœlenteron; were the polyps of all genera studied, it is possible that they might be found in some genera to be confined to particular mesenteries. The tentacles are extraordinarily sensitive; otherwise there are no special organs concerned with the world around the polyp, and so far as we know all functions of this nature are similarly limited in all corals. The same is perhaps true of the essential functions of the stomodæa and mesenteries. The latter always bear a fixed relationship to the septa, which may be all intermesenterial, or have their last-formed cycle extramesenterial. The stomodæum may have one groove at one end, or one at either end, or a groove between each pair of mesenteries, the coupling of which, together with the differentiation of those attached to the stomodæum, may be of taxonomic value. The presence or absence of directive mesenteries is important.†

The examination of polyps is a laborious business, entailing the use of all the powers of the microscope and varied methods of staining. Sections show little differences in the fine structure of the skeleton, so that a large collection of a species may be examined in a few hours or days, whereas each individual polyp will certainly require weeks, perhaps months. Unfortunately the polyps of most genera of solitary living corals have not yet been examined; most of these grow at considerable depths and their tissues are often irretrievably damaged when brought to the surface in dredge or trawl.

For defence, when the polyp is contracted, the nematocysts of the tentacles can scarcely be everted. Their function is rather concerned with obtaining their carnivorous food, though of course they may serve as a deterrent to the few crawling and swimming animals that attack corals. They are thrown out at the least touch, but only those of the

* *Vide* 'Quart. Journ. Micro. Sci.' LXVII, 101–122 (1923).

† Prof. Matthai's work shows the dominance of the mesenterial influences in the budding-off of polyps in colonial forms. Furthermore, considerable complications are found in most of the above parts and some of these are of undoubted taxonomic importance. Matthai ('Trans. Linn. Soc., Zool.', ser. 2, 1914; 'Phil. Trans. Roy. Soc. London', ser. B, CCXIV, 313–67, 1926; 'Cat. Madreporaria, B. Mus.' VII, 1928, and in other papers) shows the existence of several types of nematocysts, these occurring in the mesenterial filaments, stomodæal walls, massed in tentacles and scattered through the whole of the external ectoderm, but very rarely found in the calicoblastic part. The ridges between the stomodæal grooves present considerable differences. Matthai stresses the importance of the detailed structure of the mesenteries, particularly that of the pleats carrying the musculature.

We observe that Dr. M. E. Thiel classified the Astræacea on these ideas of budding, dividing them into Directivata and Dedirectivata; 'Res. Sci. Ind. Or. Meer.' II, 39 (1932).

hydromedusan *Millepora* are unpleasant to man. Clearly, protection, viz. the safeguarding of the living polyps, must be elsewhere and surely it lies in the withdrawal of the polyp tissues between upstanding septa, which are covered only by the thinnest layer of tissues. However the corallum may be formed, it is actually the main support , its first appearance being in a firm covering (basal plate) for its attachment, this sometimes extending up around its sides as a wall (*cf.* epitheca as in Flabellidæ) ; above all this serves for the first attachment of the middle lamina (mesoglœa) of the polyp. In that the skeleton bears definite relationships to the tentacles, mesenteries and necessarily to the shape of the polyp, it may be held to reflect its anatomical characters sufficiently for use in taxonomic work. Its value is the greater for this purpose in that it has diverse parts (basal plate, epitheca, septa, theca joining the septa, the outer parts of which are termed costæ, pali and columella). Some of these may be absent, all vary in their interrelationships, and each may have diverse characters, thus in marked contrast to the soft parts which *appear* to have much greater uniformity. There must be added here internal trabeculæ, tabulæ, synapticulæ, dissepiments, etc., all designed for strength and support. Finally all parts may be perforated to allow of a closer relationship of the polyp's cavities with one another.

Perhaps under all the circumstances, the skeleton is likely to reflect a sufficient sample of the polyp's anatomy to justify the founding of genera and species upon it—and, of course, it is only upon the coralla that fossil forms can be considered.* The fact is that the skeleton is convenient to the taxonomist, whereas ultimately the greatest importance lies in the living polyps.

These somewhat optimistic views on the use of the skeleton alone for taxonomic purposes require to be qualified and I would refer to Prof. Matthai's summary of the characters employed by systematists for colonial corals up to 1914† : (1) The form of growth of the colony ; (2) the nature of the intercalicinal peritheca ; (3) the flat or arched character of the dissepiments ; (4) the presence or absence of an epitheca ; (5) the character of the theca ; (6) the number of septal cycles and of the septa constituting each cycle ; (7) the nature of the septa ; (8) the presence or absence of paliform lobes and their shape, size and surface characters ; (9) the nature of the costæ ; (10) the nature of the columella. Prof. Matthai was here concerned with Astræidæ, and he adds : " none of these characters were found to have any constant value and therefore the distinctions based on them would appear to be arbitrary," and his subsequent enumerations of anatomical facts culled from the astræids and meandrids amply bear out this statement.

In the solitary corals which we are considering, nos. 2 and 3 are absent and 5 is of small importance. In dead, dredged forms and in fossil forms all characters dependent on the textures, and presence of surface structures tend to be limited by abrasions and chemical actions in the water or mud. The free edges of structures are often defective, so that all that remains is growth-form, presence or absence of epitheca, costæ, theca and pali, number and inter-arrangements of septal cycles and the nature of the columella, if present. The form of growth little affects the essential features of either polyp or calicular

* Here is a criticism of a proposed classification by Wayland Vaughan in the geological phase of his researches, regarded by him as just : " Nous ne ferons qu'une critique, unique mais importante, a cette classification, c'est qu'elle n'a rien de phylogénétique ; les espèces et les genres de tous les temps et de tous les pays y sont melangés, aucun charactère évolutif n'apparent." M. Dollfus in ' Rev. Crit. de Paléozool,' 65–7 (1906).

† ' Trans. Linn. Soc.' XVII, 2 (1914).

structure. Within individual species of upstanding corals may be found broad-columned coralla, conical, cornute attached or free, the latter resulting from a loosening of the basal attachment or more rarely from fission of the narrow base near the same.* The calices may be round, oval or compressed in each of the above shapes ; in the last, the ends of the calice may reach the same level as the sides, or, may be lower, giving an arched appearance from side view (Pl. I–III).†

In contrast to the above forms are a large number of discoid coralla, parallel evolutions scattered, usually as genera, through several families. The theca extends out horizontally from the calicular centre, and the whole skeleton should be covered by the polyp tissues. Most of these discs were at some time attached and later became free, apparently without breakage, but in *Fungia*, as in certain species of the epithecate *Flabellum*,‡ the stalk still containing polyp tissues may break, a form of strobilization ; how far regrowth from the attached part is a regular phenomenon is unknown, but I have seen examples in these two genera. Some *Fungia*, *Fungiacyathus* (Pl. VII, figs, 19, 20) and perhaps other genera, go further in that their discs split from the centre, each part completely regenerating the corallum. In all corals this power of regeneration is an amazing phenomenon, called forth not only by regular autotomy, but by any accidental damage. We have seen it in nearly all simple genera, of which we have large series, and observations suggest that it is a universal power provided that the pieces concerned each contain a pair of mesenteries. The formation reproduced is that of the original polyp and its skeleton, almost invariably without loss or gain of any part (*cf.* also *Tropidocyathus*, Pl. V).

The cycles of septa seem to be always hexameral to start with, but in a few adult species and occasionally in odd specimens, possibly young forms, an octameral symmetry is found. Ten is very rare except during growth, and we know of no case where it is taxonomic in solitary corals.§ Very commonly the 6 septa of cycle II grow equal in all respects to those of cycle I, giving a 12-symmetry. The side septa do not alter their position materially where the mode of growth leads to a compressed form, but septa of size equal to those of I and II form in the gaps produced on either side of the two terminal septa together with pali if these are found in the species. By this means a 16-symmetry results, but in some of the *Caryophyllia* this is a stage passed through in forming the the 24-symmetry (Pl. I). This has 24 systems, each consisting of one of these first-sized septa (I–III) on one side and three others between it and its neighbours, a pair very small on either side of an intermediate. Conspicuous septal teeth are uncommon in solitary corals ; when present they are usually the terminations of growth lines in the septa and these are often further marked by rows of low spines. Pali follow septa in texture and in the number in their cycle with considerable regularity ; there is usually one to each system. The true or "essential" columella is a lime concretion on the basal plate extending up vertically into the polyp's tissues. It is a rod, a plate, or a series of rods ; these rods, often ribbon-like, are joined by trabeculæ from the larger septa. In

* *Caryophyllia* provides good examples ; see corals in the ' John Murray and " Discovery " (in Press) Reports '.

† The references are to plates and text-figures in Vol. V, No. 7, of this same publication and are inserted solely for the convenience of the reader, who may not be acquainted with the genera mentioned.

‡ Figured in ' Marine Invest. in S. Africa,' II, pl. iii, 16, iv, 22–34 (1902). Note also the wing formation, sometimes developing into hollow struts, and the greater development of the latter as seen in fig. 34. Where there are such rootlets the central stem is retained.

§ In colonial corals ten septa are found in *Madracis*.

the absence of a true columella such trabeculæ may fuse to form a false or " parietal " columella. The columellar surface extends up to the level of the calicular rim or is situated even down to half the depth of the calice ; the fineness and number of the rods also vary and we have seen them fused into a large solid mass.

Usually the genera in solitary corals are determined by the presence or absence of any of the above parts by a generalized form of growth and by the character of the columella if present. Species are often determined on details of these, helped by the number and inter-relationships of septa and pali. With a long series of specimens of solitary corals the specific characters emerge, but no single corallum can be regarded as a type. The growth-form of attached species is often likely to be a difficulty, since at times the polyp seems to be able to lay down additional corallum on any pre-existing skeleton, perhaps thickening its theca externally to the extent of completely burying its costæ and internally solidly filling-up its calice.*

An ever present difficulty is the determination of the adult size of a species—and it is certain that many species have been founded on growth-stages. Unfortunately, the polyp is of little help here, since it may hold its nearly ripe generative products for many weeks. After shedding, regeneration of ova or sperm masses does not take place indefinitely, gaps appearing in any mesentery where they occurred. However, the difficulties in respect to simple corallites are as nothing compared to colonial reef-species whose shapes may be as fluctuating as those of our trees, varying from the types of the Japanese garden of our shops to the same kinds rooted in a protected valley or on an open hillside.

To correlate the different growth-forms attained by coral genera and species with varied environments is as difficult in simple as in colonial corals. In all genera the polyp commences with an upright growth, presumably to raise its mouth above the detritus-layer. It may then become a discoid corallum or remain permanently upright. In the latter any advantage in a cone shape as compared with a broad base can scarcely be conceived, where, as is generally the case, the available space for the polyp tissues within the calice is the same. Often from the same dredging, while most corallites are cones, some happily attached to stone are almost of equal diameter throughout. Freedom, when not genetical, is often a matter of weight ; the cone tumbles and from it a bent horn may be produced by further growth, the mouth bending upwards away from the ground, the whole calicle comfortably rocking if there are any slight currents. Physical abrasion or competition with other sedentary organisms in non-epithecate forms may gradually kill the polyp from its attached base upwards, and then, as it were by a last effort as its edge-zone retreats, the outside of the corallite is overlaid by a fresh deposit of corallum, completely obliterating the costæ. Density of the corallum is often the only means of determining whether this has happened, since the reduction and even absence of costæ is not an uncommon variation. After killing, the exposed corallum is subject to solution, which may remove costæ, but occasionally is found what appears to be a surface deposition of lime from the sea-water. The epitheca lies outside the costæ and, where a theca is

* Any removal of carbon dioxide raises the pH of the water and thus may cause a precipitation of carbonate of calcium (McClendon, ' Carnegie Publ.', 252–8, 1918). The coral skeleton would form the natural nucleus for the deposition of aragonite crystals, should any action of the tissues in their retreat raise the pH. Sections failed to show evidence of such, but the deposition of crystals on crystals would naturally follow the structure of the coral skeleton and no line of demarcation between that formed under the polyp and that deposited from the sea-water might be visible.

present, encloses continuations of the mesenterial spaces of the polyp which continue down between it and the theca, these overlapping its upper edge (*cf. Antillia*). Even in upright corals, normally devoid of epitheca, a thin surface lamina of corallum may often be found, not connected with the basal plate below. This may be developed further in the perforate *Balanophyllia*,* within some species of which all stages may be found from an absence of epitheca to its presence completely covering the corallum almost to the edge of the calice. In the Flabellidæ the epithecate wall may be greatly thickened by an internal deposition of corallum, and any external damage is thus repaired. The epitheca, however, is not nearly so subject to solution or abrasion as any other parts of the coral skeleton that may be exposed to the seawater. Young unattached forms of the colonial *Goniopora*, as dredged, are completely covered by polyp tissues; in further growth an epithecal plate forms where their edges touch the sand or hard mud. As growth proceeds the colony thickens, sinks into the bottom and a series of flat circular rings of epitheca may form above one another, protecting its living edges from the deposits.

To turn to environmental effects, the sea-water everywhere has about the same relative proportions of its chemical salts and hence there can be no effects here, but corals do not appreciate brackish water, seldom continuing to live where there is less than 25% of salts. Heavy rain over four hours of exposure at low tide was never found to kill reef-corals, and the effects of river-flooding seemed to be due rather to sediment than to salinity.

The skeletons of corals are not affected by any ranges of temperature recorded in natural environments so far as can be judged from our knowledge of Gulf Stream, Red Sea and Mediterranean areas. Reef-corals, even when they are attached above low spring levels, are seldom killed by the heatings they receive at low tide, when the water often exceeds 100° F. Cold may have its effects, since there is a tailing-off in genera, species and numbers towards Antarctica, where it is certain that available food shows no decrease.

Water movements are greatest near the surface, and very shallow-living, simple corals have almost invariably a strong column nearly as broad as the calice itself and of little height, to which may be added a tendency to develop the epitheca if present. The common discoid *Fungia* with *Halomitra* and other allied genera are found in depressions and hollows of surface reefs, and owing to their exceptionally massive skeleton are little disturbed, even by the waves.

Strong-columned forms are also characteristic of rocky bottoms, while it is only in still waters that attached cones can persist. The polyp tissues of epithecate corals sometimes overflow their cup. They may thus form hollow rootlets, the calicle continuing to grow vertically. This is common in *Flabellum* (*Rhizotrochus*) and is particularly noticeable in specimens attached to rock. On soft mud nothing lives, but fine deposits are usually smooth on the surface and somewhat hardened below, a quite suitable place for all free forms whatever their shape. Here the perforate *Stephanophyllia* has generally a flat

* This genus has a number of shallow-water species, 7 having been obtained in the Maldives. *B. regularis* makes a habit of growing under rocks or in crevices into low broad columns, seldom more than 5 mm. high; their number is often such as almost to form a society, their depth seldom more than a fathom and often between tide-marks. *B. gemmifera* prefers rather deeper water but still wave-affected; it grows into columns about 20 mm. high, often broadening at the calices. Both of these only produce an epitheca where crowded by other organisms. *B. affinis*, also living in very shallow water on a bottom of sand or mud, is a free conical form, never showing any epitheca. All these species were kept alive; they seemed quite immune to drifting mud.

discoid skeleton, rather heavier than turbinolid discs, and is often found on relatively soft bottoms such as occur in atoll lagoons as well as on ocean banks at 100 to 200 fms.; its polyp tissues are exceptionally thick and firm and completely cover the skeleton, recalling their condition in *Fungia*. On the same class of bottom *Stephanocyathus* (Pl. VI) starts as an attached form, and grows out into a thin disc, which becomes free. The polyp enlarges, starts to thicken its whole skeleton and to grow out heavy costal spines near its edge. On attaining its adult diameter it grows vertically and the result is a very massive skeleton, its base killed where it has sunken into the deposit below. Of primitively upright growers some show wide, open cones, varying to cup or even saucer shapes, their centres below bedded in the deposit and dead; loose-lying forms are invariably cornute. The flattened, compressed, cone-shaped *Sphenotrochus* and some other free genera, which remain completely covered by polyp tissues, like this fine sandy bottom; they are usually well-costulated or covered with low spines and all parts look healthy, no dead patches. A more extreme case is *Tropidocyathus* (Pl. V) which may attain a height of 20 cm., its calice 16 by 11 mm.—88 specimens from one collection were all living without any dead patches, 90% being regenerated individuals from vertically split-up fragments (*cf. Diaseris*-forms of *Fungia*). Both these genera must have lain on their sides, and how they lived at all is a mystery. The perforate *Endopachys* with its flattened cone is found in the same environment but it has side wings which may function to keep it upright; it also has a complete covering of polyp-tissues and buds frequently form upon its wings. *Heterocyathus** and *Thecopsammia* like this same bottom, the former preferring rather harder ground than the latter; they are rounded forms of even diameter completely covered by polyp tissues save where the commensal *Aspidosiphon* of their basal parts has its mouth and respiratory openings. They are the only corals with any possibility of movement, and this is no more than a slight burrowing into the surface due to their worms.

Species of *Paracyathus* (Pl. IV), *Balanophyllia* and *Caryophyllia* have also been dredged from the same class of environment; these are normally attached corals with thick columns. They seem to become detached from the bits of shell or dead coral that form their base and then to lie on their sides. Their polyp is soon killed by the deposit, but it makes a fight by budding-off daughter coralla on its sides, usually near the mouth of the calice. These grow vertically upwards above the deposit and the old dead corallum serves as an attachment; the whole, as the new corals get heavy again, tumbles over and more buds are formed, so as to produce a simulation of more regular colonial formations. *Desmophyllum* also forms clusters, but its corallites often grow to a great size, their stems correspondingly thickening; they seem to prefer rocky ground and they could certainly stand up to any current.

It is not conceivable that pressure can have much effect, and, while genera like the discoid *Deltocyathus* (Text-fig. 3, VI, VII, 14 and 16), *Bathyactis* (Text-figs. 1 and 2 above) and *Leptopenus* living normally at some considerable depth, are characterized by delicate coralla, there is no such general phenomenon correlated with depth and there are no examples of fixed columnar forms with similarly thin coralla.

If they can exist in shallow water, solitary corals (*Fungia*, which have symbiotic algæ, excepted) seem to shun the light, and this is also noticeable in the creeping forms

* Forty-three specimens illustrative of the variation of *Heterocyathus æquicostatus* are shown in pl. iii of ' Marine Invest. S. Africa ', III, 1904.

with separated corallites, such as *Cladocora* and *Culicia*. They attach themselves to the undersurfaces of rocks or in crevices and frequently are found living on the sides of reef channels where the scour of the tide is considerable. On reefs the *Cœnopsammia*-forms of *Dendrophyllia* grow into incrusting masses in any crevices below slabs of limestone or dead coral in contrast to the freely-branching and upstanding growths that may be found in most species of the genus living 50 fms. below.* The position is such that we are almost compelled to look to the question of illumination for an explanation of the restriction of so many solitary corals to deep water, all questions of food having failed us after the examination of large numbers of polyps. Perhaps the real position is concerned with the effect of light on the complex of organisms associated with corals in shallow waters. Where there is sufficient illumination there is vigorous algal growth, with its associated fauna of crawling animals, a few swimming forms visitors. Tunicates, Polyzoa, sponges and other sedentary organisms will maintain themselves against plants, even growing over them. Corals never seem to be able to do so, their larvæ preferring the bare glass of submerged bottles and never settling on or maintaining themselves against plants and other sedentary organisms contained in the same bottles.

So far as we know colour is not associated with depth or any other environmental character, forms coloured by symbiotic algæ omitted. We have not enough information, spirit polyps losing their colour except in the case of some browns and blacks, the corallum below always white, except where stained after the death of the polyp. Dredgings show that there is no especial tone correlated with any environment below the light zone (*c.* 50 fms.) and, while most species of a genus bear resemblances in colour to one another, we think of the dense black, brilliant reds and yellows merging into dark browns of such genera as *Dendrophyllia* and *Balanophyllia*, and the tendency to shades of purple in *Flabellum*. Usually the corallum bleaches, but in *Tropidocyathus*, *Sphenophyllia* and *Sphenotrochus* it always retains its brown colour.†

This exposure of our ignorance of corals leads us to plead for light, but could some naturalist tell us how the corallum is formed ? Until this is determined its taxonomic value cannot be duly estimated. While the biologist thinks mainly of the living and the geologist of the dead, cannot they come together ? They find an indissoluble bond in their study of vertebrates and surely there is analogy in madreporarian skeletons, to the hard parts of which the polyp tissues are attached. It may be convenient for museums as storehouses to separate the fossil and living vertebrates, but the taxonomist, who professes to be a specialist solely on the one side, can be deemed only by reason of his historical authority to fall within the scientific fold. There can be no serious difficulty in completely blending the simpler living and fossil Madreporaria, usually small drawer-specimens, and having them examined by the same specialists. This proposal certainly applies to other phyla, as well as to all Actinozoa, but meantime we commend it as a commencement for the consideration of the British Museum, Smithsonian Institute and other similarly great museums.

* No further reference is given to the genus here, nor to *Madrepora* (syn. *Lophohelia*) as the attempts to correlate their growth forms with environment are somewhat speculative. They live at the same depths (also *Oculina*) and their calices are well separated on their stems and represent a form of growth never found in the colonial corals of atoll or other reefs.

† At Porto Praya, Canary Islands, a species of a massive *Dendrophyllia* and one of *Balanophyllia* grow slightly below the low tide level. Both species, determined on their coralla as species, are either red or yellow, forms thus coloured growing alongside each other.

PRESENTED

DESCRIPTION OF PLATE I.

FIG. 1.—*Balanophyllia cumingii* Ed. & H. × 1.

FIG. 2.—Above : *Balanophyllia præcipua* n. sp. × 1. (Three coralla.)
Below : *Balanophyllia serpentina* Vaughan. × 1. (Four coralla.)

FIG. 3.—*Balanophyllia diffusa* (Harrison and Poole). × 1.

FIG. 1.

FIG. 2.

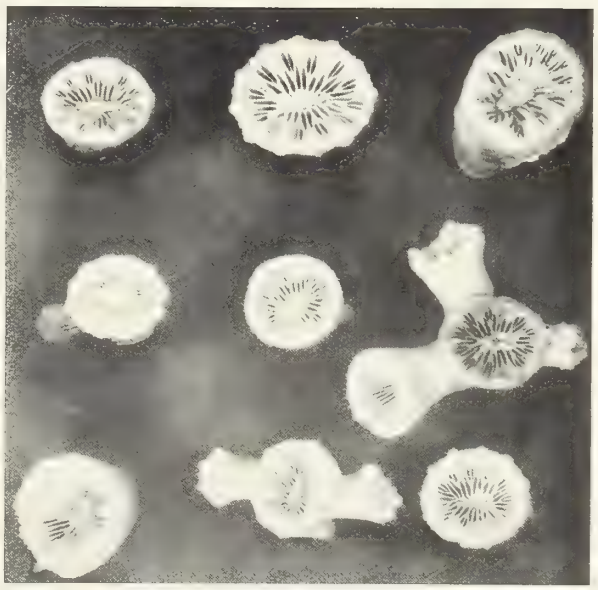

FIG. 3.

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DESCRIPTION OF PLATE II.

FIG. 4.—*Balanophyllia diffusa* (Harrison and Poole). × 1.

FIG. 5.—*Dendrophyllia horsti* n. sp. × 1. Calicular view.

FIG. 6.—*Dendrophyllia horsti* n. sp. × 1. Side view.

FIG. 1.

FIG. 5.

FIG. 6.

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STOMATOPOD LARVÆ

BY

G. E. H. FOXON, M.A., F.L.S.

(University College, Cardiff)

WITH FOUR TEXT-FIGURES

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WITH FOUR TEXT-FIGURES.

INTRODUCTION.

This collection of Stomatopod larvæ is interesting in that it contains examples of several "classical" types such as formed the basis of Claus's "Die Metamorphose der Squilliden". Unfortunately, however, it does not permit of any further larvæ being referred to specific adults, although some suggestions are put forward concerning certain of the *Alima* larvæ of *Squilla*. Turning to the other genera, in *Pseuderichthus* some peculiarities of *P. communis* have been pointed out; in *Lysioerichthus* attention has been drawn to Tattersall's questions concerning *L. duvaucellii*, and an attempt has been made to draw together under the name *L. rostratus* a number of very similar larvæ which appear to belong here and may be the larvæ of *Lysiosquilla multifasciata*. The specimens in the collection enable certain of the developmental stages of *Lysioerichthus rostratus* and *Coronideriehthus bituberculatus* to be followed. The genera *Gonodactylus* and *Odontodactylus* are not represented in their larval stages.

The greater part of the examination of the collection was carried out in 1937 in the Zoology Department of the University of Glasgow. It was decided that it would be better if the completion of the report was delayed until that on the adult Stomatopoda by Dr. Chopra was available, as it would enable references to that report to be made. The report on the adults reached me in January, 1939, and, in the interval, I had also received a few further specimens which had been sent to Dr. Chopra, but which were too immature to be considered in his report. This account of the larval forms has been concluded in the Department of Zoology and Comparative Anatomy, University College, Cardiff.

I wish to express my thanks to the following: Lt.-Col. R. B. Seymour Sewell, F.R.S., for the opportunity of examining this collection; the Trustees of the British Museum (Natural History) for allowing me to examine material in the Museum and for the loan of specimens for comparison; Prof. E. Hindle and Prof. W. M. Tattersall for the facilities offered for my work at Glasgow and Cardiff respectively.

* From the Departments of Zoology in the University of Glasgow and the University College of South Wales and Monmouthshire.

LIST OF STATIONS AT WHICH STOMATOPOD LARVÆ WERE OBTAINED.

Red Sea.

7. 16.ix.33. 13° 58′ 48″ N., 42° 22′ 42″ E.
   2 m. Plankton, 100–0 m., oblique.
   2 m. Stramin, 100–0 m. ,,
   Alima spp., *Pseuderichthus communis.*

Gulf of Oman.

71. 26.xi.33. 25° 35′ 00″ N., 56° 42′ 18″ E., to 25° 43′ 00″ N., 56° 39′ 18″ E.
   Otter trawl, 106 m. *Alima* spp.

76. 29.xi.33. 24° 13′ 54″ N., 59° 03′ 30″ E., to 24° 16′ 42″ N., 59° 06′ 06″ E.
   1 m. Stramin, 300 m. *Alima* sp., *Pseuderichthus ?distinguendus.*
   1 m. ,, 1800 m. of wire out. *Alima* sp.
   2 m. Tow-net, 2800 m. ,, ,,

Northern Area of Arabian Sea.

61. 8.xi.33. 61A, 23° 02′ 48″ N., 64° 31′ 54″ E., to 61B, 23° 02′ 30″ N., 64° 41′ 00″ E.
   1 m. Stramin, 500–0 m. *Alima* sp.
   1 m. ,, 1000–0 m. ,,
   1 m. ,, 1500–0 m. ,,
   1 m. Tow-net, 1500–0 m. ,,
   2 m. ,, 2000–0 m. ,,

   8–9.xi.33. 61C, 23° 02′ 12″ N., 64° 33′ 39″ E., to 61D, 23° 02′ 30″ N., 64° 15′ 54″ E.
   5 cm. Net, 0 m. *Alima* sp., *Lysioerichthus rostratus.*
   1 m. Stramin, 1000–0 m. *Alima* sp.
   1 m. Tow-net, 1000–0 m. ,,
   1 m. ,, 1500–0 m. ,,
   2 m. ,, 2000–0 m. ,,

86. 6.xii.33. 19° 20′ 24″ N., 69° 24′ 18″ E., to 19° 25′ 42″ N., 69° 22′ 54″ E.
   Agassiz trawl, 759–1024 m. *Alima* sp., *Lysioerichthus duvaucellii.*

Central Area of Arabian Sea.

96. 19.xii.33. 10° 54′ 42″ N., 61° 20′ 54″ E., to 10° 53′ 18″ N., 61° 22′ 24″ E.
   2 m. Tow-net, 400–645 m. *Lysioerichthus duvaucellii.*

172. 29.iv.33. 9° 40′ 24″ N., 54° 03′ 36″ E., to 9° 42′ 18″ N., 54° 39′ 00″ E.
   1 m. Net, 400–0 m. *Alima* sp., *Lysioerichthus rostratus.*
   1 m. ,, 850–0 m. *Alima* sp., *Lysioerichthus rostratus, Coroniderichthus bituberculatus, Pseuderichthus ?distinguendus.*
   2 m. ,, 2091–0 m. *Alima* sp., *Lysioerichthus duvaucellii, Pseuderichthus ?distinguendus.*

Southern Area of Arabian Sea.

131. 11.ii.34. 1° 39′ 06″ S., 61° 13′ 48″ E., to 2° 07′ 30″ S., 61° 21′ 12″ E.
   1 m. Stramin, 1500 m. of wire out. *Alima* sp.

Maldive Area.

145d. 2.iv.34. 4° 58′ 42″ S., 73° 16′ 24″ E.
1 m. Net, 100–0 m., vertical *Alima* sp.
1 m. ,, 500–0 m. ,, *Lysioerichthus duvaucellii.*

Gulf of Aden.

186. 5.v.34. 13° 32′ 30″ N., 49° 13′ 06″ E., to 13° 32′ 00″ N., 49° 15′ 18″ E.
1 m. Net, 575–0 m. *Alima* sp.
1 m. ,, 600–0 m. ,, *Coronideriehthus bituberculatus.*
2 m. ,, 950–0 m. ,,

A NOTE ON THE CLASSIFICATION OF STOMATOPOD LARVÆ.

When reporting (1932) on the Stomatopod larvæ of the Great Barrier Reef Expedition, 1928–29, I gave a key to show that the larvæ could be classified in the same way as were the adults by Kemp (1913). Gurney (1937) has since criticized this key, and suggested that the arrangement of the larvæ proposed by Giesbrecht (1910) is more natural. Although some of Gurney's criticisms are valid and do point out weaknesses in my scheme, I am not able to accept the whole of them; in particular his view that the larval development of the genera *Lysiosquilla* and *Coronida* is fundamentally different from that of the other genera must be rejected. From a study of the appendages of the *Lysiosquilla* larvæ collected by the Barrier Reef Expedition, it was concluded that the thoracic appendages 3, 4 and 5 are first used for swimming, and, later, although they do not disappear, undergo transformation into feeding organs. During this transformation they undoubtedly pass through an apparently functionless stage. Should such larvæ hatch later with the appendages in this functionless stage, it would appear obvious that, in the course of evolution, these functionless appendages would undergo complete suppression and would appear later still and in their final form, so giving rise to the type of larva found in the other genera. Thus it was argued that the type of development seen in *Squilla*, *Pseudosquilla*, *Gonodactylus* and *Odontodactylus* is not distinct from that of *Lysiosquilla* and *Coronida* but in all probability is derived from it.

It is obvious that opinions will differ as to the amount and the significance of adaptation to development exhibited by the larvæ, and the present writer believes that a classification based mainly on adult characters and those appearing late in larval life is more likely to lead to a correct appreciation of the interrelationships of the genera than one based mainly on larval development, for the course of larval development is likely to be highly modified by mechanical factors such as the amount of yolk present in the egg and the degree of development on hatching.

It is clear that any attempt to classify the Stomatopoda must take into account both larval and adult characters. It is quite illogical to have one classification for adults and another for larvæ. Kemp's classification of the adults is now universally accepted, and a return to Giesbrecht's scheme, based on the larvæ, would be quite unacceptable to most workers. A point of very great importance made by Kemp is that *Pseudosquilla* is the genus most nearly related to *Squilla*, and no classification can be acceptable which does

not bring out this fact. However, it is not considered that no advance can be made and, below, a "key" to the genera is given which attempts to take account of Gurney's criticisms, and to give expression to them without upsetting the main points of Kemp's classification.

KEY TO THE GENERA OF STOMATOPODA WITH SPECIAL REFERENCE TO LARVAL FORMS.

A. Larvæ hatch with the anterior thoracic appendages biramous and natatory (*Erichthoidina* stage), but which later undergo a transformation to the typical chelate form. The "hand" of the fourth thoracic appendage is rounded, often broader than long, and more than twice as big as that of the fifth thoracic appendage. In the raptorial claw the upper margin of the propodus in the adult is finely pectinate and the ischio-meral articulation terminal.

1. Propodus of raptorial claw broad and dactylus slightly inflated at the base . . . . . *Coronida.* [*Coronideriehthus.*]

2. Propodus of raptorial claw slender and no trace of inflation at the base . . . . . *Lysiosquilla.* [*Lysioerichthus.*]

B. Larvæ hatch with the raptorial claw developed and no appendages on the third, fourth and fifth segments of the thorax; when the appendages of these latter segments appear, the "hand" of the fourth is oblong and generally longer than broad and scarcely bigger than that of the fifth thoracic appendage.

1. In the raptorial claw the ischio-meral articulation is terminal and the upper margin of the propodus in the adult is usually finely pectinate.

(*a*) The first larva hatches with four pairs of pleopods and develops into an *Alima.* Telson with more than four intermediate denticles between submedian and lateral denticles . . . . . *Squilla.* [*Alima.*]

(*b*) The first larva hatches with five pairs of pleopods and develops into an *Erichthus.* Telson with less than four intermediate denticles between the submedian and lateral denticles . . . *Pseudosquilla.* [*Pseuderichthus.*]

2. In the late larva the ischio-meral articulation of the raptorial claw ceases to be terminal, and becomes situated at a point in advance of the proximal end of the merus. The upper margin of the propodus of the raptorial claw is not finely pectinate.

(*a*) The spines of the telson are greatly elongated.
Odontodactylus. [*Odonterichthus.*]

(*b*) The spines of the telson are not greatly elongated.
Gonodactylus. [*Gonerichthus.*]

SYSTEMATIC NOTES.

Squilla, J. C. Fabricius.

The *Alima* larvæ of *Squilla* form a very large part of the collection, but unfortunately no larva can be referred to an adult with any degree of certainty. Our knowledge of this group of larvæ is undoubtedly growing gradually, and it seems possible to obtain now a general idea of the main distinctions between larvæ which belong to different groups of the genus, but which characters indicate specific differences is still a matter which is open to doubt.

To judge from the work of Giesbrecht (1910) and Brooks (1879), the larvæ of the "*mantis*" group would appear to be characterized by a somewhat triangular carapace which is not unduly enlarged. Komai and Tung (1929) have recently described a larva, which they refer to *S. oratoria*, and we may conclude that the larvæ belonging to other species near this will not be very different. Indeed some very similar larvæ are very abundant in the present collection, and are assigned to the "*nepa*" group to which *S. oratoria* is closely allied. In 1932 I tentatively referred a larva from the Great Barrier Reef to *S. lata*, and, more recently, Lebour (1934) has described a somewhat similar larva which she suggests is actually the larva of *S. lata*, the Barrier Reef specimens belonging to the "*lata*" group. This type of larva, which has been referred to the "*lata*" group, is not far removed from the "*Alimerichthus*" type of the older authors. This latter type cannot be referred to a group of adults, but a point which is worth noting is that specimens are known from both the Indo-Pacific region and the South Atlantic, and this must be borne in mind when any attempt at referring them to a specific adult is made. The facts of distribution appear to be very important, and no species of *Squilla*, with the exception of *S. armata*, which is restricted to southern latitudes, is known from both Atlantic and Pacific regions. Nevertheless, Komai and Tung (1929) refer a larva from Japan to *Alima subtruncata* Jurich, which is common in the Atlantic ; but it seems very unlikely that they can be specifically identical. Similarly Lebour (1934) on these same grounds has questioned the identity of certain forms referred to *Alima hyalina* by various authors.

It has frequently been pointed out that the only constant difference between an *Alima* larva and an *Erichthus* is to be found in the spinulation of the telson. The present large collection of *Alima* larvæ has drawn my attention to the very different way in which the telson develops here as compared with the *Erichthus* type. To begin with, the two types are much alike—a fact which probably explains why Claus (1872) called his fig. 12 an *Erichthus* ; at this stage the submedian teeth are well separated and the intermediate teeth are well anterior to them. During later stages the intermediate teeth are carried posteriorly so that they are nearly level with the submedians, the latter coming very close together and taking up the positions which they will occupy in the adult. In *Erichthus* larvæ, on the other hand, although the submedian teeth come close together in the adult stage, they remain widely separated in the larval stages, and, as the figures of Giesbrecht (1910) clearly show, the telson undergoes much transformation in the post-larval stages. I have elsewhere (1932, p. 382) remarked on the early assumption of adult characters in *Alima* larvæ, and have pointed out that the prolongation of larval life, which appears to have taken place in this genus, comes at the end rather than at the beginning of the larval stage ; this of course emphasizes the distributive function of these larvæ.

Brooks (1886), and more recently Lebour (1934), have urged that the only satisfactory method of dealing with the problem of the specific identity of the larvæ is to rear them until the post-larva is obtained ; until this can be done there is little hope of making great progress in the study of these forms. Komai (1932) has described how the larvæ attributed to *Squilla oratoria* can be dried, stained pink, powdered, bottled and sold under the name of " Ebi-no-sei " (essence of shrimp) ; it would appear a point for debate whether this is not a more desirable fate for *Squilla* larvæ than to occupy space in museum collections under the somewhat hopeless designation of *Alima* sp.

It is convenient to deal with the *Alima* larvæ in three groups : firstly, those near *Squilla nepa*, secondly, those near *Alima robusta*, and thirdly, those near *Alima multispinus*.

Squilla spp. (" *nepa* " group).

[*Alima* spp.]

Occurrence.—Station 7 (Red Sea), Station 61 (Northern area of Arabian Sea), Stations 71, 76 (Gulf of Oman), Station 131 (Southern area of Arabian Sea), Station 145 (Maldive Area), Station 172 (Central area of Arabian Sea), Station 186 (Gulf of Aden).

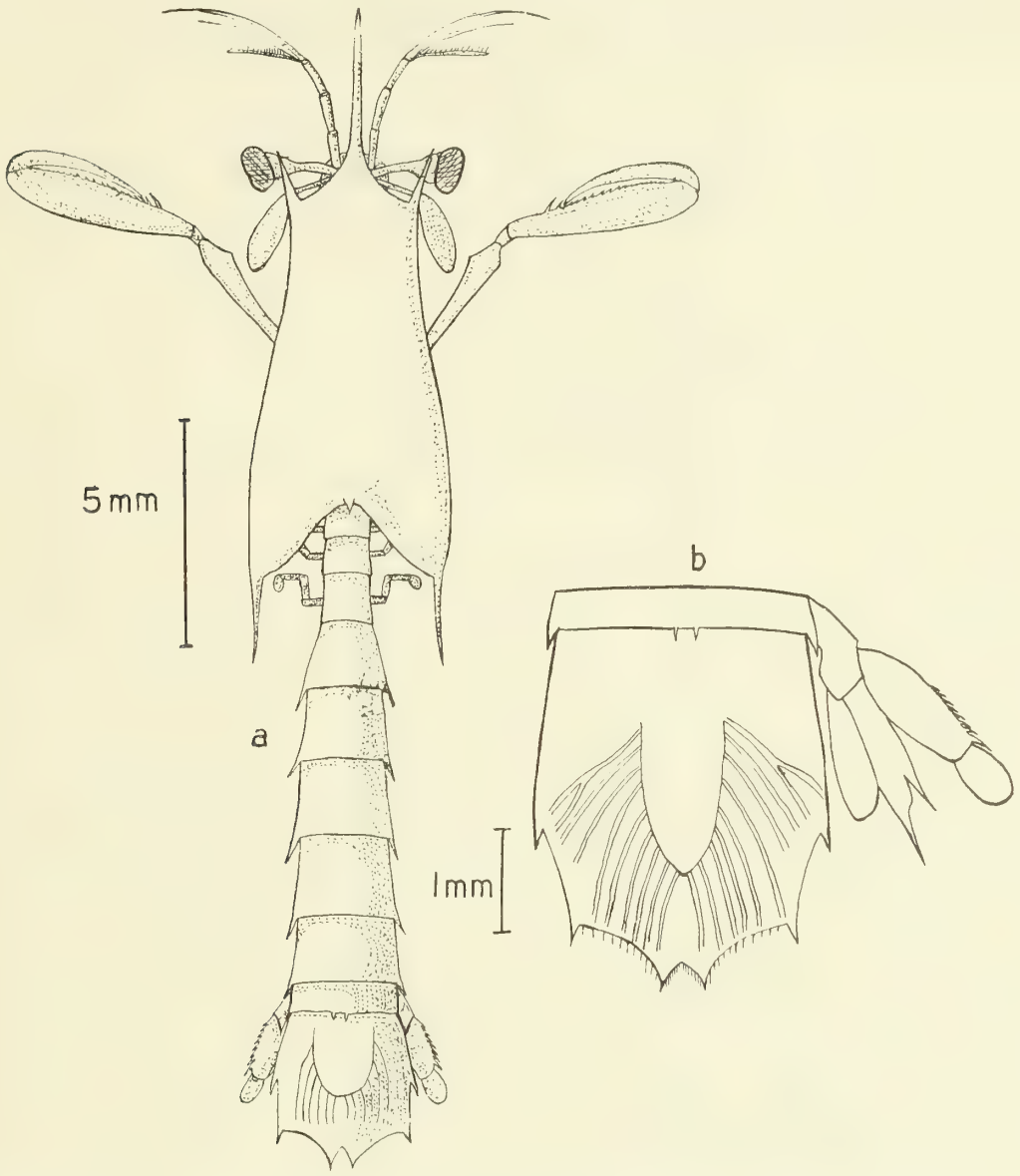
Remarks.—These specimens all resemble the larvæ described by Komai and Tung (1929) from Japan as the larvæ of *Squilla oratoria*. There is no doubt that the John Murray Expedition specimens belong to closely related species, but they are slightly larger than the larvæ of *S. oratoria*, not being fully grown at 25 mm. In the present state of our knowledge it is impossible to say whether more than one species is represented in the collection, but it is highly probable that there are several present.

By far the greatest numbers were obtained at Station 186, where close on four thousand specimens all apparently belonging to the same species were obtained ; a large number of specimens were also taken at Station 7, these being more fully developed. It is considered unlikely that the larvæ from these two stations belong to the same species, although it is possible. But, from their general similarity to the larvæ of *Squilla oratoria*, it is fairly certain that these larvæ belong to adults of the " *nepa* " group. One from Station 7, about 25 mm. in length, is represented in Text-fig. 1 ; the carapace, which, at this stage, leaves the last three thoracic segments uncovered dorsally, is very flat, although the " zœa " spine is raised on a small triangular prominence at the posterior edge of the carapace ; it is also very thin and delicate in appearance. The telson is rather longer than broad.

It is attractive to suggest that the large numbers found at Station 186 belong to *Squilla investigatoris*, which is very abundant in this region (see Chopra, 1939), but, apart from the distribution, these is little other evidence to support this view. With regard to those from Station 7, which is in the Red Sea, it is of interest to note that Dollfus (1938) has given a revised list of adult Stomatopoda found in this area. He records five species of *Squilla*, including *S. massavensis*, *S. wood-masoni* and *S. multicarinata* ; the shape of the uropod (see Text-fig. 1, *b*) shows that the larvæ might well belong to any of these species. The peculiar markings on, or in, the telson are suggestive of *S. multicarinata*, but further evidence will have to be forthcoming before a definite allocation of the larva to an adult can be made.

Three rather damaged specimens, slightly bigger than those from Station 7, and belonging to the same or a nearly related species, were caught in the Gulf of Oman at

Station 71. One of these specimens showed five spines on the dactylus of the raptorial claw (including the terminal one). This is the typical number of the *quinquedentata* group, so that there is a chance that these larvæ do not belong to the "*nepa*" group;



TEXT-FIG. 1.—*Alima* sp. (*a*) Dorsal view of a specimen 25 mm. long. (*b*) Telson of a similar specimen showing the markings referred to in the text.

but it is most likely that another spine might be added at a subsequent moult. It is, however, worth noting that Dollfus (1938) has recorded *S. gonypetes* from the Red Sea.

At the remaining stations fewer specimens were taken and at some stations only one specimen. It will be noted that all the stations at which these larvæ occurred were comparatively near land—a point which will be further commented upon in the section on distribution.

Squilla sp.

[*Alima* sp. near *robusta*, Jurich, 1904.]

Occurrence.—This species was not met with nearly so frequently as the preceding type ; several specimens were taken at Station 61 (Northern area of the Arabian Sea), 2 specimens at Station 86 (same area), and 3 at Station 172 (Central area of the Arabian Sea).

Distribution.—Jurich's specimens were from the Indian North Equatorial Current.

Remarks.—This species is very like those of the preceding group except for a larger and longer carapace ; probably the adult is not far removed from the "*nepa*" group.

Squilla sp.

[*Alima multispinus* (Claus).]
[*Erichthus multispinus*, Claus, 1872.]
[*Alimerichthus multispinus*, Borradaile, 1907.]

Occurrence.—Station 7 (Red Sea), Station 61 (Northern Area of the Arabian Sea), Stations 71 and 76 (Gulf of Oman).

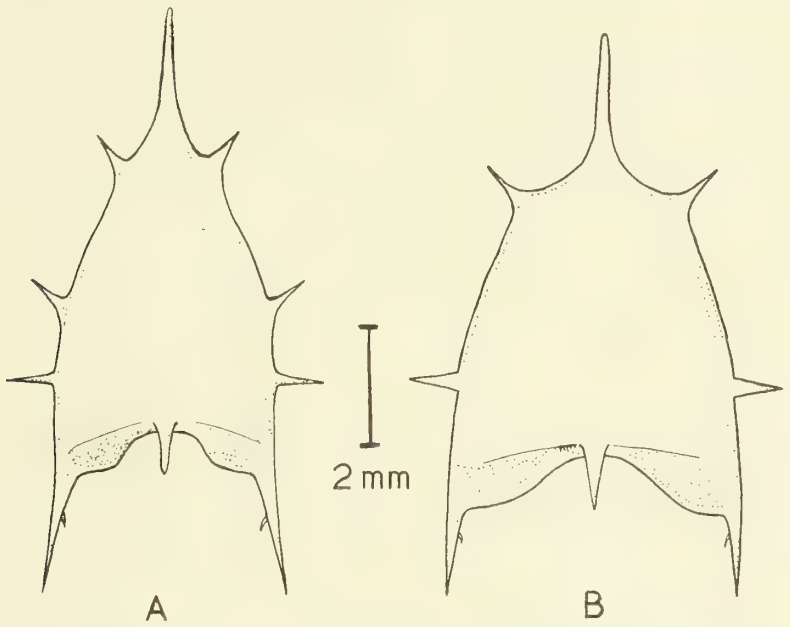
Distribution.—Claus's specimen came from the Indian Ocean, and Borradaile's specimens from Saloman Atoll and Desroches Atoll.

Remarks.—It is uncertain whether the specimens in the collection all belong to this species, or whether some of them belong to another, nearly related, one ; but, as I am unable to suggest an adult to which these larvæ might belong, I prefer to deal with them together rather than to create a new larval name.

The specimens fall into two groups. Firstly those which closely resemble Claus's figure (12) of *Erichthus multispinus*, but bear, in addition, the small tooth on the spines of the hinder angles of the carapace mentioned by Borradaile. Borradaile says that in his specimens the foremost of the spines on the lower edge of the carapace is very much larger than is shown in Claus's figure ; in the specimens in this collection this spine is directed more ventrally than its posterior companion, to which it is almost equal in size. The fact that in Claus's figure this spine appears shorter may be due to foreshortening. These typical specimens were found as follows : seven at Station 7, one at Station 61 and one at Station 76.

Secondly, in addition to the typical specimens, others were found at Station 7 (4), Station 71 (2) and Station 76 (1) which are almost identical with *Alima multispinus*, but have only one laterally directed spine on each side of the carapace. Text-fig. 2 shows the two types of carapace in dorsal view for comparison ; this second type appears to be that figured by Claus in his fig. 30. Claus's specimen was 18 mm. in length, and his figure shows eight teeth, including the terminal one, on the dactylus of the raptorial claw and eight spines on the exopodite of the uropod. A specimen from Station 7, 18 mm. in length, shows seven incipient teeth on the raptorial dactylus and nine spines on the uropod. A specimen of the more typical *A. multispinus* 20 mm. long from Station 61 shows four dactylar teeth already free and three more still covered by the larval skin, and the exopodites of the uropods show eight spines on one side of the body and seven on the other. If these two types of larvæ really do belong to two species of adult *Squilla*, the adults must be very closely related.

When any attempt to refer these larvæ to their adults is made the comparatively large number of teeth on the raptorial dactylus should be borne in mind. It is unlikely that larvæ of this general shape belong anywhere near *S. nepa* or *S. oratoria*, which would rule out the possibility of their belonging to *S. investigatoris ; S. armata* is unlikely for geographical reasons ; therefore, of the species of *Squilla* listed by Kemp (1913) as having this large number of teeth on the raptorial dactylus, only *S. raphidea* and *S. annandalei* remain. However, this can hardly be considered as more than a guess.



Text-fig. 2.—*Alima multispinus*. Dorsal view of carapace of (*a*) typical form ; (*b*) the same or a closely related species.

Pseudosquilla, Dana.

According to Kemp, this genus is to be regarded as that most closely allied to *Squilla*, but its larvæ are quite different in appearance from the *Alima* type, and, in their earliest stages at least, are difficult to separate from those of *Gonodactylus* and *Odontodactylus*. It is largely this difficulty that has led to the modifications in the " key " given above. However, I believe that a useful character by which these larvæ can be distinguished from all other types of Stomatopod larvæ is by the very early development of the uropods, which in quite early stages—not the first, however—come to be equal in length to the telson, the spinous process from the base of the uropod being especially conspicuous.

Another peculiarity of some of the larvæ of this genus should be mentioned here ; it concerns the pectination of the upper margin of the propodus of the raptorial claw. This fine pectination of the propodus is a character typical of all adults of this genus, and in the majority of larvæ it can be seen developing during growth. It is well marked in the following figures of *Pseuderichthus* larvæ : *P. elongatus*, Hansen (Claus, fig. 25), *P. affinis*, Borradaile (Claus, fig. 23), and the larvæ of *Pseudosquilla constricta*, *P. caudata* and *P. ferussaci* (?), figured by Giesbrecht (1910) on his plate 11, figs. 4, 57 and 77 respectively.

However, when we turn to *Pseuderichthus communis*, Hansen (larva of *Pseudosquilla ciliata*), and *P. distinguendus*, Hansen (larva of *Pseudosquilla oculata*), we find that in Claus's figures (Claus, figs. 26, 27A, 27B, 27C) this pectination is absent, as it is in the specimens in the British Museum collection. Through the kindness of Dr. Smith, of the University Museum of Zoology, Cambridge, I have also examined Borradaile's specimens, and these too, show that the pectination is absent. However, in some cases it is possible to distinguish a few scattered spinules on the upper margin of the propodus of the raptorial claw. According to Bigelow (1931) the " monodactyla " stage of *Pseudosquilla oculata* has a series of fine hairs in this position in place of the pectinations of the adult. Jurich (1904, pl. 38, fig. 5) figures a specimen which he attributes to *Pseuderichthus distinguendus*, and which shows pectination on the propodus of the raptorial claw ; however, in view of all the other figures and my examination of certain specimens, it must be concluded that Jurich was mistaken, either in placing the larva in this species, or in drawing the pectination on this joint ; it may be noted that Hansen (1926) has likewise questioned the accuracy of Jurich's drawing of *Lysioerichthus duvaucellii*.

Pseudosquilla ciliata (Fabricius).

[*Pseuderichthus communis*, Hansen, 1895.]

Occurrence.—Station 7 (Red Sea), 10 specimens.

Distribution.—The adult of this species is known to have a very wide distribution throughout the " tropical and warmer temperate seas (Hansen, 1926) ". A list of places at which the adult has been found has been given by Kemp (1913), who includes a record for the Red Sea made by Nobili ; he also gives a list of occurrences of the larva which is as follows : " Indian Equatorial current (Jurich) ; from Ceylon (Tattersall) ; and from the Chagos Archipelago, Alphonse Is., Amirante group, Providence Is., and between Mauritius and Cargados (Borradaile). In the Atlantic it has been recorded from the Sargasso Sea and the N. Equatorial current (Hansen)." The Red Sea would appear therefore to be a new locality for the larva, and we should also add to the Atlantic distribution the specimens found by the " Terra Nova " off the Brazilian Coast (Calman, 1917). Chopra (1939) records a " monodactyla " stage from Station M.B. II (South Arabian Coast).

Remarks.—The specimens are all about 21 mm. in length and are quite typical.

Pseudosquilla sp. (? *oculata* (Brullé)).

[? *Pseuderichthus distinguendus*, Hansen, 1895.]

Occurrence.—Station 76 (Gulf of Oman), 1 specimen, Station 172 (Central area of Arabian Sea), 12 specimens.

Distribution.—This well-known larva has been recorded both from the Atlantic and Indo-Pacific regions.

Remarks.—The specimens, which I refer with a considerable degree of hesitation to this species, are all small. The largest is one from Station 172 and measures about 15 mm. in length. The remaining specimens are all smaller than this and do not exceed 10 mm. long. They differ from the older larvæ of this species, which have been described by

other authors, in having all the spines of the carapace longer, and they possess a fairly well-developed " zœa " spine. In general appearance they somewhat resemble *Pseuderichthus affinis* as it is shown in Claus's fig. 23, but can be immediately distinguished from it by the absence of any secondary spines near the base of the postero-lateral spines and by the presence of spinules on the underside of the rostrum. These larvæ are referred to *P. distinguendus* rather than to *P. communis* on account of the prominence of the "zœa" spine ; from Claus's figures it would seem that the former species tends to retain this spine longer than the latter. A point which may be worthy of note is that the spinules on the upper margin of the propodus of the raptorial claw are quite prominent even in the early stages.

Lysiosquilla, Dana.

Lysiosquilla maculata (Fabricius).

[*Lysioerichthus duvaucellii* (Guerin).]

[*Lysierichthus Duvaucellii*, Hansen, 1926, with synonymy.]

[*Lysioerichthus duvaucellii*, Tattersall, 1906.]

[*Lysierichthus duvaucelli*, Borradaile, 1907.]

Occurrence.—Stations 86 (Northern area of Arabian Sea), 96 (Central area of Arabian Sea), 145 (Maldive area) and 172 (Central area of Arabian Sea).

Distribution.—This species is known from almost the entire Indo-Pacific region.

Remarks.—Hansen (1926), in his " Siboga " report, has treated this larval species in a somewhat peculiar fashion. He has apparently overlooked the records of both Borradaile and Tattersall, and, in the latter case, this is an unfortunate omission, as Tattersall raised important questions which should be taken into account by later workers. Also Hansen gives some reasons for believing that this larva belongs to *Lysiosquilla maculata*, and omits the fact that this relationship was first suggested, and, indeed, practically proved, by Brooks (1886), who found that one of the later larvæ in the " Challenger " collection displayed the pigment-bands so characteristic of the adult.

Tattersall (1906) drew attention to several discrepances in the descriptions by various authors of the larvæ referred to this species, perhaps the most important being the presence or absence of the " zœa " spine. He suggested that the larvæ referred to this species might really belong to more than one species. The larvæ in the present collection do not, unfortunately, throw any great light on this matter ; of the three larger specimens the one from Station 86 had no " zœa " spine, while the other two, from Station 96, have this spine present, otherwise the three specimens, all about 22 mm. long, appear equally developed.

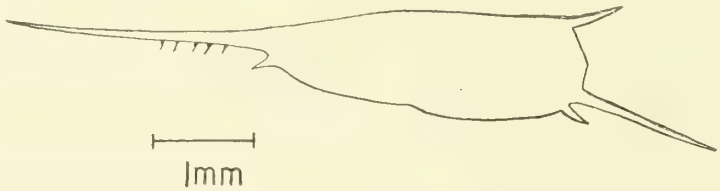
I also refer to this species some very early larvæ found at Stations 145 (2 specimens) and 172 (3 specimens). They appear identical with the larvæ called by Claus (1872) *Erichthoidina armata* and shown in his fig. 3. Claus's specimens have, however, been referred by Hansen (1895) to the Atlantic species *Lysierichthus edwardsii* (Eyd. and Soul.). My chief reason for referring these small larvæ to *L. duvaucellii* is that they possess median lateral spines on each side of the carapace.

Lysiosquilla sp. (? *multifasciata* Wood Mason).

[*Lysioerichthus rostratus* (Borradaile).]
[*Erichthus* (? *Odonterichthus*) *rostratus*, Borradaile, 1907.]
[*Coronideriehthus rostratus*, Foxon, 1932.]
[? *Erichthus* sp., Claus, 1872.]
[? *Lysioerichthus* β Tattersall, 1906.]
[? *Lysioerichthus* sp., Komai and Tung, 1929.]

Occurrence.—Station 61 (Northern area of Arabian Sea), 1 specimen, Station 172 (Central area of Arabian Sea), 10 specimens.

Distribution.—If all the larvæ mentioned in the synonymy above really do belong to the same species it will be seen that it has a very wide distribution. Borradaile's specimens were from Alphonse Is., and the specimens which I described as belonging to the same species as his were from the Great Barrier Reef. If, as I hope to show, the other larvæ mentioned also belong to the same species the distribution extends to Japan, and Tattersall's specimens were from the Gulf of Manaar.



Text-fig. 3.—*Lysioerichthus rostratus*. Side view of a carapace of a specimen 7 mm. long.

Remarks.—The specimen from Station 61 and one of those from Station 172, although not so well developed as Borradaile's specimens, are, nevertheless, quite typical; of the remaining nine specimens from Station 172 some are definitely *Lysioerichthus rostratus*, but, in the very youngest specimens, there is great possibility of confusion with the first stages of *Coronideriehthus bituberculatus*; in early stages these two species are indistinguishable. The later development of this species can be followed in the specimens in the present collection. Text-fig. 3 shows the carapace of the 7–mm. stage; here the postero-lateral spines reach as far as the end of the telson so that the carapace length is the total length of the larva. The raptorial claw is developed but the three following appendages are still biramous. The carapace shows the infolding of the posterior half of the sides, which is not nearly so marked in this species as it is in *C. bituberculatus*; the rostrum shows its characteristic curving and has five conspicuous spinules on its under surface; the spine at the base of the postero-lateral spines continues prominent and does not disappear as in *C. bituberculatus*, and the "zœa" spine remains much shorter than in that species.

It seems very likely that *Erichthus brevispinosa*, Claus (1872, figs. 4 and 5) are young stages of this species; Tattersall (1906) has pointed out that these figures are not of *Gonodactylus* larvæ as Brooks (1886) thought.

There are several problems concerning this species which must be discussed. Firstly, are all the synonyms mentioned above valid?

In 1932 I stated that the specimens of this species from the Great Barrier Reef were "identical with both the figures given by Claus and with the actual specimens collected

by the 'Sea-Lark' Expedition". It has now been noticed that Claus's fig. 19*g* of the raptorial claw shows no pectination on the upper margin of the propodus—a character which I remarked at the time was present in this species. Through the kindness of Dr. I. Gordon I have been able to re-examine two of Borradaile's co-types. These show distinct pectination on this joint; in neither specimen, however, is the rostrum complete, so that the presence or absence of the upward curve could not be determined. I believe that I am now dealing with the same species as Borradaile, but that some doubt must exist as to whether he was correct in assuming his specimens to belong to the same species as those figured by Claus, for the latter shows no pectinations on the propodus of the raptorial claw and the rostrum is straight and not curved. From the figures given by Tattersall (1906) and by Komai and Tung (1929) it seems most likely that these authors were also dealing with this species, but Komai and Tung do not discuss the possibility of their larvæ belonging to the same species as those of Tattersall, although his paper occurs in their list of references.

Tattersall also describes the development of his larvæ and it is very similar to what I have recorded here; this is an additional argument for regarding these two forms as belonging to the same species.

Secondly the question arises as to whether this larval species belongs to *Lysiosquilla* or to *Coronida*.

In 1932 I suggested that this species belonged to *Coronideriehthus*. As pointed out above, the larvæ in their youngest stages are very similar to those of *C. bituberculatus*, but, for other reasons, it seems more satisfactory to regard these larvæ as *Lysioerichthus*. Firstly, if this was a *Coronida* larva we should expect to find two common species of *Coronida* in the Indo-Pacific region; this is not the case. However, this is not a conclusive argument, as Calman (1917) has remarked that the abundance of the larvæ of *Coronida bradyi* in the warmer parts of the Atlantic is in striking contrast to the extreme rarity of the adult. Secondly, the introduction of this species into the genus *Coronida* would introduce a new carapace shape for this genus, for both *Coronideriehthus armatus* and *C. bituberculatus*, when looked at from the dorsal aspect, have a carapace that is triangular in outline and also is highly vaulted. If we were to accept the *Coronida* hypothesis, we would have to assume that the peculiar variations of carapace shape found in the larvæ of *Lysiosquilla* are to some degree paralleled in *Coronida*. The shape of the larva under discussion is, however, one that is already known from the genus *Lysiosquilla*, and Komai and Tung (1929) point out that their larvæ are very like those ascribed to *L. occulta* by Giesbrecht (1910). Thirdly, the degree of inflation of the propodus of the raptorial claw, by which it is possible, according to Hansen, to separate *Coronida* larvæ from those of *Lysiosquilla*, is not an easy point to determine, and although in some specimens this joint appears rather inflated, in others it is less so. Altogether in view of these arguments it seems preferable to refer this larva to *Lysiosquilla* rather than to *Coronida*.

As to the view of Komai and Tung that this larva may be that of *Lysiosquilla multifasciata*, it is impossible to advance any evidence which might lead to a positive conclusion. The following details of distribution of the adult may be pointed out. The distribution seems wide and extends to Japanese waters; Kemp (1913) doubted Nobili's determination of specimens from Obock in the Red Sea, but Chopra (1939) points out that this species undoubtedly does live in the Red Sea, and also records nine adults from Station 72 (Gulf of Oman).

Coronida, Brooks.

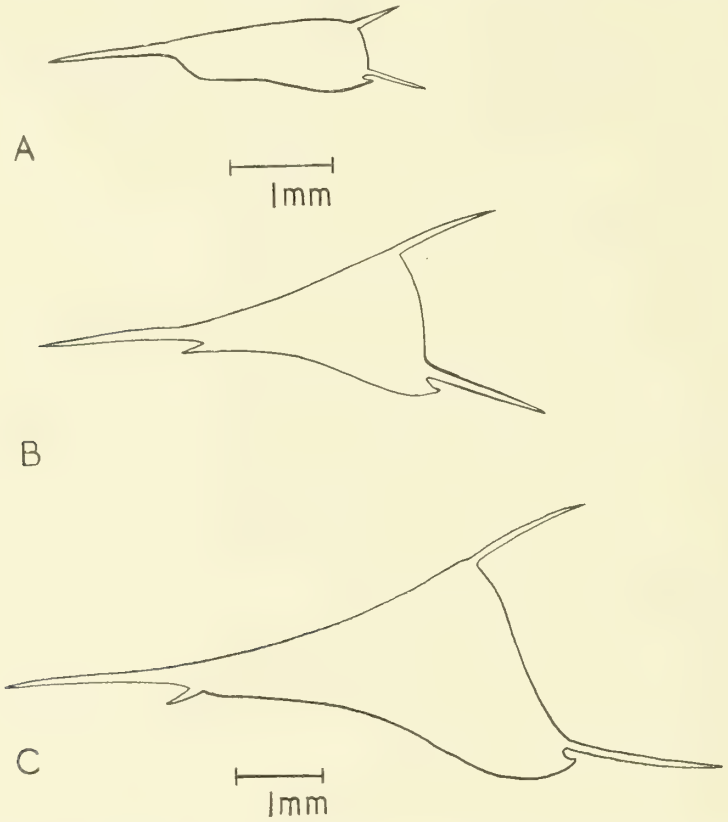
Coronida sp. (? *trachurus*, v. Martens).

[*Coronideichthus bituberculatus*, Hansen.]

[*Coronideichthus bituberculatus*, Hansen, 1926 with synonymy.]

Occurrence.—Station 172 (Central area of Arabian Sea), 9 specimens; Station 186 (Gulf of Aden), 2 specimens.

Distribution.—This species is known from the Indian North Equatorial Current (Jurich, 1904), and Hansen's (1926) specimens came from the Phillipines.



Text-fig. 4.—*Coronideichthus bituberculatus*. Side view of carapace at various stages of development: (*a*) " Erichthoidina " 4-mm. stage; (*b*) 6-mm. stage; (*c*) 12-mm. stage.

Remarks.—The specimens in the collection cover nearly the whole of the developmental stages. The largest specimen, which measures 12 mm., from Station 186, is nearly fully grown; the only conspicuous difference between this and Claus's (1872) fig. 15 is that in this specimen there are no conspicuous spinules on the underside of the rostrum. It is extremely difficult to differentiate between the young stages of this species and those of *Lysioerichthus rostratus*; a length of 6 mm. is the earliest stage at which it is possible to be quite certain that a larva belongs to this species; these have the raptorial claw developed, but the three following pairs of appendages are still biramous and the antero-lateral spines of the carapace have appeared (Text-fig. 4*b*). By the time that a length of 8 mm. has been attained the transformation of the remaining thoracic appendages has commenced, and this is complete in specimens of 12 mm. The hook-like spines at the bases of the

postero-lateral spines of the carapace have a peculiar history. Text-fig. 4*a* shows an Erichthoidina of 4 mm. which, from the proportions of the " zœa " and postero-lateral spines, and from the fact that the edges of the posterior half of the carapace show signs of ventral folding, is probably to be referred to this species ; here there are as yet no antero-lateral spines on the carapace, but the hook-like spines at the bases of the postero-lateral spines are clearly seen. These hook-like spines become more prominent in subsequent stages, but, by the time that the 12-mm. stage (Text-fig. 4, *c*) is reached they have begun to decline, and Claus's figure of a fully developed larva shows that they have disappeared ; this sequence of events is somewhat different from what happens to these same spines in *Lysioerichthus rostratus*.

Komai and Tung (1929, p. 216, fig. 1) refer to *Lysioerichthus* sp., a larva which is not unlike the present species ; they do not, however, suggest that it belongs to this or to any other species. Indeed this part of their work is somewhat difficult to follow, as despite the fact that Hansen (1895) long ago pointed out that differences exist between the *Lysioerichthus triangularis* of Milne-Edwards and that of Brooks, they have regarded the two species as synonymous.

DISTRIBUTION.

(*a*) Horizontal :

It has been pointed out above that the large collections of *Alima* larvæ were made at stations relatively near the large land masses, and this seems to go a long way to providing proof that the elongation of larval life found in this genus is of importance in distribution. *Alima* larvæ in small numbers were, however, found at all the stations at which Stomatopod larvæ were taken except Station 96, where a single *Lysioerichthus duvaucellii* was obtained. This species was also found at several other stations, but not in the Red Sea, Gulf of Aden or Gulf of Oman. *Pseuderichthus* larvæ were, on the other hand, found both in the Red Sea and Gulf of Oman and also at Station 172 ; at the latter station *Lysioerichthus duvaucellii*, *L. rostratus*, *Coronideriehthus bituberculatus* and two types of *Alima* were also found.

To summarize, one receives the impression that *Alima* larvæ occur almost everywhere, but in greatest numbers near the coast ; that *Pseuderichthus* larvæ are also likely to be found near land ; and that *Lysiosquilla* larvæ are those most likely to be found furthest from land. As for *Coronideriehthus bituberculatus*, its occurrence at only two stations, one in the Gulf of Aden and the other Station 172, does not permit of any generalizations.

(*b*) Vertical :

At Station 61, during the day, although various larvæ were caught in different nets fishing at depths down to 2000 metres (2265 m. of wire out), none was taken at the surface. But, during the night, the surface net caught *Alima* larvæ of the " *nepa* " and " *robusta* " types and also a specimen of *Lysioerichthus rostratus*, but larvæ were still being taken in the 2000 m. net. It would appear that, although there was no definite upward migration of the larvæ at night, there is a tendency to follow the general rule found amongst plank-tonic crustacea to move upwards at night. It should be pointed out, however, that Borradaile (1907) records several Stomatopod larvæ as having been taken at the surface during the hours of daylight.

The occurrence of the large specimens of *Lysioerichthus duvaucellii* in the deeper nets at Stations 86, 96, 145D and 172, together with the fact that the only *Alima* larvæ in which spines were developed on the raptorial dactylus were caught in the Otter Trawl at Station 71, suggest that, in these genera at least, the final larval moults take place nearer the bottom than the earlier ones.

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WITH NOTES ON TWO SPECIES OF PENNATULACEA

BY THE LATE

PROFESSOR SYDNEY J. HICKSON, F.R.S.

WITH ONE PLATE AND TWELVE TEXT-FIGURES

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INTRODUCTION.

As the marine fauna of the Indian Ocean has been already investigated by the naturalists associated with the "Valdivia", "Investigator" the Pearl Fisheries, the "Percy Sladen" and other expeditions it was not expected that the collections of the "Murray" Expedition would bring to light many new or specially interesting species.

Only two new species of Gorgonacea have been added to the long list of species that have already been described. One of these, *Acabaria mabahissi*, was found off Cape Guardafui, and is in many characters absolutely distinct from all the other species of its genus. There were five specimens in the collection showing considerable variation in the form of the corallum and in colour, but none of these varieties show any approach to the characters of other species. It is, in fact, quite discontinuous with other species, and, so far as is known at present, confined to this one locality off Cape Guardafui.

Some of the most striking features of the growth form of these colonies are probably due to the activities of symbiotic Crustacea. One of these, found loose in the bottle, was identified as a species of *Uroptychus*, but another one, probably belonging to the same species, was found—and remains—imprisoned in the meshwork of the branches of the flabellum.

The other new species, *Stenogorgia sewelli*, differs from other species of the genus by the enormous size of its spindle-shaped spicules. This is, of course, a very variable character and standing by itself it is not a very reliable one for specific diagnosis. It is possible that in this respect intermediate varieties will be found between the new and older species ; but taking into consideration several other characters of minor importance I think the constitution of *St. sewelli* as a new species is justified.

In my report on the Pennatulacea (1937*b*, p. 109) I remarked that a feature of special value in the Murray collection was the presence of a large number of specimens of some of the species as affording an opportunity for the study of variations. In the Murray collection of Gorgonacea four species are represented by several or many specimens. One of these, which I have referred to the species *Chrysogorgia flexilis*, is represented by several large specimens and numerous fragments from six stations at depths of 229–1450 metres. A careful examination of preparations of the polyps of several branches of a single large colony and of most of the other specimens and fragments from the same and different colonies has shown so much variation in the size of the polyps and the characters of the spicules that the specimens must be regarded as examples of one widely distributed deep-sea species.

Another species of the same genus, *C. cupressa*, is represented by 70 specimens of various sizes from one locality. The characteristic " bottle brush " form of the colonies is common to all of them, and in other characters there is comparatively little variation. The general conclusions are, therefore, that *C. cupressa* is a perfectly distinct species and that the only other species of the genus in the Indian Ocean is *C. flexilis*.

Another result from the investigation of these specimens is to throw considerable doubt on the validity of Versluys' genus *Metallogorgia* (p. 308).

The discovery of two specimens of *Solenocaulon ramosum* at Station 24 off Cape Guardafui is also of some special interest. They are almost identical in size and other characters with the type specimen from the Maldive Archipelago, which I described nearly forty years ago.

The peculiar belt-like outgrowths of the stem of this species (see Text-fig. 1) were considered to be gall-like structures due to the activities of some epizoic crustacean. This view has been contested by other authors, and one of them definitely asserts that they are essentially " inherent characters of *Solenocaulon* " and have nothing to do with crustacean epizoites.

This interesting problem is fully discussed on p. 271.

I have again to thank Col. Sewell and Capt. A. K. Totton for much valuable advice and assistance, and also Prof. J. Gray for allowing me full facilities to work in the Zoological Department of the University of Cambridge.

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Order GORGONACEA.

Sub-order SCLERAXONIA.

Family Briareidæ.

Solenocaulon ramosum Hickson (1900*b*, p. 498). (Text-fig. 1.)

There are two specimens and some fragments of this species from Station 24, 73–220 metres, off Cape Guardafui.

They are 250 and 270 mm., respectively, in length, and they have a solid, unbranched

stalk 60–68 mm. in length. The base of attachment of both of them is unfortunately missing.

Above the stalk there are five belts in each specimen, 20–30 mm. in length and 10–20 mm. in diameter. These tubular belts are nearly all complete, that is to say, the two wing-like outgrowths from the main stem are fused together at their free edges to form a short wide tube with a large aperture at both ends.

From the free edges and along the line of suture of the belts numerous branches of various lengths arise bearing a large number of polyps. These branches are flattened or deeply grooved on one side, or solidly cylindrical according to their length.

According to a note made by a naturalist on board the ship, these specimens were, when alive, white with pink polyps.

The preserved specimens are all brown in colour and it seems probable, as there are no pink or red spicules in any of my preparations, the pink colour of the living specimens is due to one of those soluble colouring matters that are so frequently seen in living Alcyonaria. The brown colour of the preserved material may be due to a thin deposit of mucus which spreads all over the colonies.

In all these characters and in many others these specimens, from a depth of 73–220 metres off Cape Guardafui, agree very closely with the type specimen from 71 metres from Suvadiva atoll in the Maldive Archipelago, which I described and illustrated in 1900*b* (p. 498, pl. xxvii). Since the original description of the species was published there has been a good deal of severe criticism about its validity.

The characters of the spicules do not differ materially from those of other species of the genus and the fact that in the type specimen the polyps were less contracted than in any of the others was considered by Thomson and Simpson (1909, p. 154) to be " a matter of little importance ".

The only other distinguishing feature of the species therefore is the presence of the broad belts which I believed to be due to the activity of an epizoic crustacean.

In my original description I expressed some hesitancy in constituting a new species for it on the ground that, as there was only one specimen to examine, intermediate forms might be found between the tubular formations of other species of the genus and the belts of *Solenocaulon ramosum*. Such intermediate forms, however, were not found in any of the eleven specimens of the genus in the collection from the Maldives.

Miss Harrison (1908, *a* and *b*, p. 39) described a specimen of *S. ramosum* from the Bay of Bengal which was 850 mm. in length and bore six incomplete and three complete belts and was said to agree in all points with the type except in its great size and entire absence of colour. It is unfortunate that neither the exact locality nor the depth from which this specimen came are recorded.

The greater number of belts may also be considered as a point of difference between her specimen and the type.

As we have now three more specimens showing the same essential characters as the type, the species is no longer known by the character of a solitary specimen. Moreover, as the four specimens were found in three localities 1000 miles or more apart the species cannot be regarded as a purely local variation. The principal difficulty, therefore, in regarding *S. ramosum* as a good species is removed.

The character that the polyps are less contracted than they are in any other species of the genus that I have examined may be a matter of little importance, but it is interesting

that it is the same in all the new specimens as well as in the type, and is due to the spicules of the crown and points being more numerous, more closely set and thicker than in any other species (Hickson, 1900*b*, p. 499).

It is true that in the form of the spicules and in other anatomical features there is very little to distinguish *S. ramosum* from the other species of the genus, and therefore the significance of the belt becomes a matter of the greatest importance.

These large wide belts are only found in *S. ramosum*, although in other species of the genus long, irregular or interrupted tubes and foliate expansions are of frequent occurrence. In my original paper I expressed the opinion that they are gall-like structures due to the activities of epizoic Crustacea.

Stiasny, however, in a recent paper (1937, p. 195) declares that the belts, tubes and similar structures are inherent characters and have nothing to do with crabs. They are not, according to his view, pathological, but perfectly normal structures.

It is not necessary to discuss here the seven reasons he gives in support of his opinion because the evidence that they are gall-structures seems to be overwhelming. I will only refer to some facts that have been described since 1900, which throw important light on the problem.

In the new species *Acabaria mabahissi* (p. 274), also from the Murray Station 24, there is a tubular stem and wide irregular spaces between the two fan-shaped expansions of the branching part of the colonies, and there are grooves on many of the secondary branches. The internal surface of all these spaces and the concave surfaces of the grooves are all quite smooth and present a general resemblance to the similar surfaces of *Solenocaulon ramosum*. A specimen of the Galatheid crab *Uroptychus* was found free in the bottle and another crab belonging, probably, to the same species was and remains imprisoned in the flabellum. It is true that no crab has been found *in situ* in any specimen of *Solenocaulon ramosum*, but considering the fact that the belts of this species have a wide aperture at both ends it would be very surprising if any crabs that might have been there did not escape as they were dragged up from great depths of the ocean and then emptied out on to the deck of the steamer.

In other species of Solenocaulon symbiotic Crustacea have been found. Nutting (1911) says of a species he refers to *S. sterroclonium* (p. 5) that "the passages are inhabited by a Macruran crab" and of a *S. jedanense* (p. 10) "some of the specimens bear symbiotic Brachyuran crabs".

It is well known to carcinologists that several species of

TEXT-FIG. 1.—*Solenocaulon ramosum.*

Crustacea are symbiotic or associated with Alcyonaria, and among the notes on stations made by the naturalists of the John Murray Expedition there are several that mention such associations.

The influence that symbiotic Crustacea may have on the growth of both hard and soft parts of other Alcyonaria may be seen in the following examples :

Gravier (1914, pp. 34 and 99) described gall-like excrescences on *Primnoïsis* and *Mopsea gracilis* caused by the Lamippid crustacean *Isidicola antarctica* and Versluys (1902, p. 4) relates that in the large polyps of *Chrysogorgia cupressa* inhabited by Copepods the spicules are more numerous and much larger than in polyps that are not so infected.

The formation of gall-like structures in other groups of Cœlenterata are not uncommon. The well-known cages of Seriatopora and Pocillopora are undoubtedly formed by and finally imprison the females of *Hapalocarcinus marsupialis*. The formation of these cages in a large specimen of Seriatopora can easily be studied. In the early stages there are two wide-open leaf-like expansions—similar to the early stages in the formation of the belts of *Solenocaulon ramosum*—which turn inwards with the growth of the corallum and fuse at their free edges to complete the closed cage.

A most interesting account of these galls was written by Semper in 1881 (p. 216).

I have described and figured (1897, p. 81) similar cages, with the crab *in situ*, on a branch of a *Millepora alcicornis* in the Liverpool Museum. Small spherical galls formed by Copepoda are also occasionally found on branches of the Stylasterina.

Tubular cavities similar to those of *Solenocaulon tortuosum* are frequently found on stony corals which are formed, not by Crustacea, but by the activities of Annelid worms. Even in the Pennatulacea a case is known of a Polychæte worm living in a tubular cavity on one side of the rachis of *Pennatula fimbriata* (see Hickson, 1916, p. 185).

The theory that all these gall-like structures are caused by the epizoic Crustacea or worms, and are in that sense pathological, is supported by the fact that in many cases, *e. g.* Seriatopora, Pocillopora, *Pennatula fimbriata*, specimens which undoubtedly belong to the same species may or may not bear the galls and bear them in different numbers or in varying positions on the corallum.

The alternative hypothesis that they are " inherent " characters of the hosts makes it impossible to find any reasonable explanation of their origin or utility.

The question whether *Solenocaulon ramosum* is or is not a good species should not be determined solely on the presence of the belts. Other considerations must also be taken into account. It is true that with these deep-sea Cœlenterata several tests of the validity of species are wanting which are available in the case of terrestrial animals, such as development and breeding. The principal guide, which is not really a test, that we can use until the development is known is discontinuity. That is to say, if a new specimen shows no connecting links with previously described species it may be regarded temporarily as a new species. If and when such connecting links are discovered it must be merged with the older species.

If *Solenocaulon ramosum* is not a valid species, to which of the older ones should it be referred ?

On this point my critics are not in agreement. Thomson and Simpson considered it to be an *S. tortuosum* and Stiasny (1937, p. 51) an *S. sterroclonium*.

But in the extraordinary regularity and size of the belts of specimens from the Maldives and the east coast of Africa, in the prominence of the verrucæ due to the larger

and more numerous spicules of the calyx and in some other minor characters there seems to be no continuity with the other species.

This may be the result of a selective adaptation for the reception of a particular kind of Crustacean which has become hereditary and therefore *S. ramosum* has acquired specific distinction, but until intermediate forms and younger stages are discovered this conception can neither be proved nor disproved.

It does not seem to me to matter very much whether it is catalogued as a species, an incipient species, an uncertain species or only a variety so long as the name is retained for future reference.

Family Melitodidæ.

Melitodes variabilis Hickson (1903, p. 809).

There are a few fragments of this species from Station 111, 73–165 metres in the Pemba Channel. They agree in every respect with some of the colour varieties from which the type specimens were described.

The nodes of the axis are dark red and the internodes vary from pale yellow to pale pink in different fragments. In one small fragment the nodes are yellow and the internodes pale pink.

The spicules are similar to those of the types in size and shape.

The principal interest of these fragments is that they prove the existence of this species in moderately deep water off the east coast of Africa.

The numerous examples of this species collected by Prof. J. Stanley Gardiner in the Maldive Archipelago were all littoral in habit, but Thomson and Mackinnon (1909, p. 198) described the species from Providence Island in 91 metres of water and Thomson and Simpson (1909, p. 169) from the Andamans in 82–493 metres and from the Gulf of Martaban in 121 metres.

The specimens in this collection came from a depth of 73–165 metres.

It seems certain from these facts that the species may be found at depths of over 100 metres without any modification in colour, variation or structure.

A similar case of extreme colour variation was found in *Chironepthya variabilis* from 37–40 metres of water in the Maldive Archipelago (Hickson, 1900*b*, p. 488). It is true that most of the deep-sea Alcyonaria are colourless and that very many of the shallow-water forms bear spicules of various colours; but several species, such as *Pennatula murrayi* from 400 metres (Hickson, 1916, p. 189) and two species of *Corallium* (Hickson, 1907, p. 6) from over 1000 metres have coloured spicules as bright as any of the shallow-water or littoral Alcyonaria.

The development of the pigment in these spicules, therefore, does not depend upon the intensity of direct sunlight.

So far as is known at present the species is confined to the Indian Ocean. The specimens from the Malay Archipelago referred to this species by Nutting do not agree with *Melitodes variabilis* in the characters of the spicules (see Hickson, 1937*a*, p. 122).

Acabaria mabahissi n. sp. (Text-figs. 2, 3, 4.)

The following statements concerning the conditions at Station 24, off Cape Guardafui, where these very interesting specimens were collected, is of special importance in connection with some characters of the species.

Col. Sewell informs me that at this station (24, 73–220 metres) the bottom was found to be uneven and steep in places. During the trawl the vessel ran into deeper water that necessitated paying out an additional 150 fathoms of trawl wire. The nature of the bottom was coarse sand and shells, with apparently occasional patches of rock and encrusting barnacles. A strong surface current was setting to the west, with occasional "tide rips", and salinity observations in the neighbourhood indicated that this surface mass of water

TEXT-FIG. 2.—*Acabaria mabahissi.*

extended downwards to at least 200 metres depth. In this region the direction of the surface current changes with the onset of the north-east and south-west monsoons ; from November to May it flows westerly, with a rate of 16–20 sea-miles per day, rising in December to 26–30 miles per day, but from May or June to October it flows eastward, with a rate of some 31–40 miles a day.

The collection consisted of two complete specimens, with the base of attachment, three large specimens without the base of attachment, and several fragments. The five specimens were as follows :

No. 1 : Size, 100 mm. high by 60 mm. broad Without base of attachment. Colour : Stems pink, verrucæ red.

No. 2 : Size, 70 mm. high by 60 mm. broad. Complete with base of attachment. Colour : Stems pink, verrucæ pale orange red.

No. 3 : Size, 80 mm. high by 20 mm. broad. Two pieces of about the same size, without any base of attachment. Colour : White, with bright scarlet verrucæ.

No. 4 : Size, 90 mm. high by 50 mm. broad. Complete with base of attachment. Colour : A uniform muddy brown.

No. 5 : Size, 60 mm. high by 50 mm. broad. Colour : Stems pale yellow, verrucæ almost white.

Form of the colony.—This seems to be as variable as the colour. In all the specimens, except No. 2, the colony is compressed to form a complex flabellum. This consists of two or more fan-shaped main branches intimately woven together at the edges, but leaving wide tubular or more irregular spaces between them. Judging from the only two complete specimens (Nos. 2 and 3) the base of attachment is a thin membrane spreading over some calcareous rock, and from this base a broad saucer-shaped structure arises, from the edges of which one (in No. 2) or more than one (No. 3) expanded stems spring. In No. 2 the single stem curves and with its secondary branches forms an incomplete tube, but shows a tendency to become flabellate at the distal extremity. In No. 3 three principal stems spring from the base, and these give rise to two main closely adpressed fans.

Although the edges of the fans form a dense meshwork by overlapping, there are very few anastomoses of the branches.

It is quite impossible to describe adequately the complexity of the ramifications of these colonies ; but special attention may be called to the following points :

(1) The colonies of the four larger specimens are flabellate in form. This may be accounted for by the fact that they live in a locality where the main currents of water flow in opposite directions.

(2) The colonies are formed by two or more adpressed flabella, affording greater resistance to the currents of water, which are strong in this locality, than a single flabellum could do.

(3) The tubular spaces, the remarkably flattened branches and the saucer-shape base of the main stem are associated with the presence of epizoic Crustacea.

As the last of these statements may be disputed, the evidence in support of it may be given here. In the bottle containing the specimens a coral-haunting crab was found, which Mr. Ramadam identified as a species of the genus *Uroptychus* ; and in specimen No. 4 another crab lies imprisoned in the meshes of the flabellum. It is evidently too large to escape. As this crab remains in its original position it has not been identified, but is probably a *Uroptychus*.

All the branches, except a few terminal ones, are considerably flattened, being in many places three times as broad as they are thick.

On all these flattened branches the polyps are strictly bilateral, springing from the edges and never from the flat surfaces. On the rare terminal branches which are not flattened the polyps are more irregularly arranged.

Each polyp is represented by a very prominent verruca and a more or less contracted anthocodia at the top of it. They vary enormously in size, but an average of several measurements of the verrucæ gives the height as 0·3 mm. and the breadth at the base 0·6 mm.

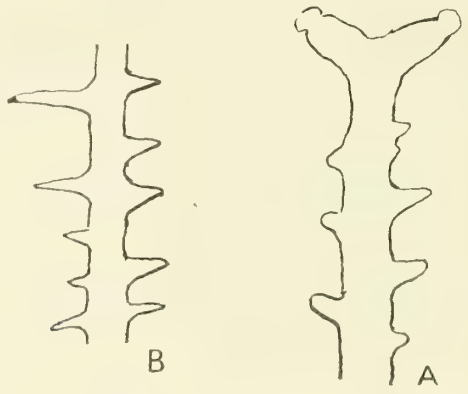
Most of the branches terminate in a characteristic way. At the tip there are two large divergent verrucæ and just below it a series of smaller verrucæ on both sides, becoming larger and larger as the distance from the tip increases (Text-fig. 3, A).

A very interesting and unique character of the species is that in the centre of each verruca there is a sharp spine-like projection of the hard axis (Text-fig. 3, B). Under no conditions of contraction can these verrucæ be withdrawn to the level of the general cœnenchym.

The axis is strongly flattened except at the extremities. The nodes are very short and almost everywhere of the same diameter as the internodes, and are therefore inconspicuous. The internodes are very hard and the surface smooth. I have not found any clearly marked fluting of the surface, such as is characteristic of the axis of most Acabarias.

The spicules of the nodes and internodes are the usual smooth rods about 0·1 mm. in length.

The colour of the internodes agrees with the colour of the cœnenchym which covers



TEXT-FIG. 3.—*Acabaria mabahissi*. A, The end of a terminal branch, × 8 diams.; B, a part of an internode of the axis showing the large spines which support the verucæ, × 4 diams.

them. The colour of the nodes of the white variety is very pale yellow and of the red varieties orange red.

The spicules.—The surface of the verrucæ bears a dense crowd of large spindles (Text-fig. 4) and clubs converging from the base towards the apex. No verruca has been seen on which any spicule is situated horizontally, at right angles to the axis of the polyp.

On the general cœnenchym the spicules are of the same types, but generally smaller. The spindles of the verruca have an average length of about 0·3 mm., but there are several seen in the preparations which are 0·3–0·45 mm. in length. The greatest diameter of the larger ones is about 0·05 mm.

Most of the tubercles are prominent, but simple, cones, but a few may be expanded to form a small leaf-like structure.

The clubs are of the same length as the spindles, but the tubercles at the thick end are more complex and crowded together than they are at the handle end. The tubercles in this region are not infrequently of the form of small thin leaves, and a few in which these leaves are larger and more numerous may be called " Stachelkeulen ".

The number of Stachelkeulen is very small, and in some of the specimens none were found. In the preparations in which they were found it was reckoned that there are not

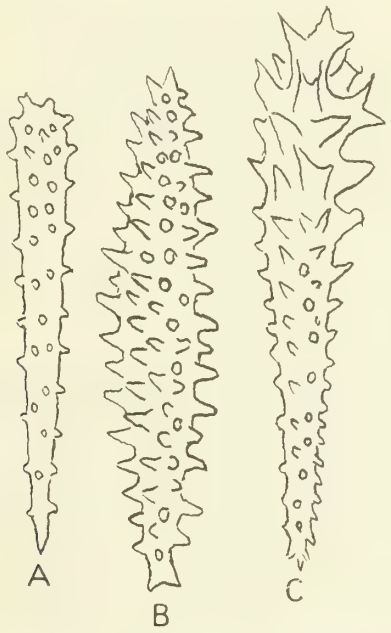
more than one in four hundred clubs. Towards the apex of the verrucæ there are some slender clubs with very small tubercles (Text-fig. 4, A). This is a very characteristic type of club.

The anthocodiæ are too much contracted and distorted to provide satisfactory preparations of the calices, but the crown consists of two or three rings of slender, bent spindles, 0·3 mm. in length, with very small tubercles. The spicules of the points are thicker and more heavily tuberculated.

No gonads were observed in any of the specimens. They were collected on October 9th, 1933.

Acabaria valdiviæ Kükenthal (1919, p. 180) from 318 metres off the Cape of Good Hope has some characters in common with *A. mabahissi*.

The polyps are bilateral in position and the verrucæ very prominent. The spicules



TEXT-FIG. 4.—*Acabaria mabahissi*.—A, A slender club at the apex of the verrucæ; B, a spindle; and C, a club of the Stachykeule type on the wall of the verrucæ. × 200 diams.

shown in Kükenthal's figures are very similar in type to those of *A. mabahissi*, but are evidently much smaller. In these characters the new species might be regarded as a variety of Kükenthal's species, and the flattened branches of the former might be regarded as one of the results of infection by epizoic crabs and not as a specific distinction from the Cape species, which has cylindrical branches and may be free from this influence. The colour difference is also one of no importance. But the arrangement of the spicules on the verrucæ and on the crown of the calyx is not a character that would be influenced by crabs or any other environmental condition, and in this respect the two species seem to be sufficiently distinct.

Kükenthal does not describe the spines from the axis which extend into the verrucæ in *A. valdiviæ*. In this respect, therefore, *A. mabahissi* seems to be unique, because it is difficult to believe that Kükenthal would not have recognized their importance if these processes were present in his species.

Acabaria erythræa Ehrenberg.

A full description of a large collection of specimens attributed to this species was published in a previous paper (Hickson, 1937*a*, p. 166). They were collected by the Murray Expedition at Station 45 off the south coast of Arabia in 38 metres of water.

Since that paper was published four small tubes containing one small specimen and some fragments from the same locality have been found. All of them show the same spicule characters as the larger specimens, and there is no special point of interest about them except that the small fan-shaped specimen, which is complete and only 30 mm. in height, would be very difficult to distinguish from *Acabaria pulchra* by external characters alone.

Sub-order HOLAXONIA.

Family Isididæ.

Genus *Isis* Linnæus.

There are some very small fragments of a colony from Station 54, 1046 metres, off the coast of Muscat.

The branches are very slender and bear widely-scattered hemispherical verrucæ, which are not bilaterally arranged.

The branches spring from the internodes.

The nodes of the axis are constricted and brown in colour ; the internodes are longitudinally grooved and pure white in colour.

The spicules are tri- and quadriradiate forms and a few small spindles. Only a few of these spicules exceed 0·05 mm. in greatest length or diameter. All the spicules are pale pink in colour.

As the larger of the two fragments is only 25 mm. in height by about 10 mm. in breadth it is impossible to identify them.

The extremely slender terminal branches, 0·1 mm. in diameter, with a very thin covering of cœnenchym, are very different from the thick, fleshy branches of *Isis hippuris*.

Moreover, the well-known species of this genus are shallow-water or littoral in habit. No specimens have been recorded hitherto from such deep water as 1046 metres. There is very good reason to believe, therefore, that these fragments belong to a species which is at present unknown to science.

Acanella africana Kükenthal (1919, p. 580).

Specimens or fragments of this species were obtained from Stations 50, 108, 109, 119, 122, 124 and 159 at depths of 640–1939 metres.

Two specimens came from a depth of 1536–1939 metres off the south coast of Arabia, some large fragments from 1280 metres off the Maldive Archipelago and all the rest from the Pemba Channel.

The specimens collected by the " Valdivia " Expedition came from numerous stations off the east coast of Africa at depths of 417–1644 metres.

The most perfect specimens are those from Pemba Channel (Station 108, 786 metres) and from the south coast of Arabia (Station 50, 1536–1939 metres). These are 240 mm.

and 200 mm. respectively in height, and both retain a part of the base of attachment, which consists of a variable number of long calcareous bands 3–8 mm. in breadth.

The greatest diameter of a main stem close to the base is 4 mm. The internodes between the base and the first whorl of branches are three or four in number and comparatively short, being only 3–8 mm. in length. Above the first branches they are usually much longer, many of them being 20–25 mm. in length.

The number of branches in a whorl is very variable, the average being about 5, but the minimum is 2 and the maximum I have observed is 6.

It is not necessary to give further details of the structure of this interesting species, because it was well described and illustrated by Kükenthal (1919, p. 580). But it was important to determine whether the specimens from the south coast of Arabia and from the Maldives were the same species as those from the east coast of Africa, and, as a result of the examination of a number of preparations of specimens from all three localities I came to the conclusion that they are identical.

This conclusion led to the consideration that the species is probably identical with the *Acanella robusta* of Thomson and Henderson (1906, p. 33) from deep water off the Andaman Islands ; but I have not been able to examine the type of this species.

I have compared my specimens with two complete colonies of a species called *Acanella normani* (Studer) from Martha's Vineyard, off the Atlantic coast of the U.S. of America. According to Kükenthal this species is identical with *A. arbuscula* of Johnson, which seems to be the prevalent species of this genus in deep water in the eastern side of the Atlantic Ocean.

From these observations and from a study of the literature of the genus I have come to the conclusion that *A. africana* and *A. robusta* of the Indian Ocean are distinct from the Atlantic species. However, it is quite possible that, when the variability of the species is better known, it may be proved that there is only one widely distributed but variable species. *Acanella* is a typical deep-sea genus and, like so many others, is not divisible into a number of clearly defined species. In this case, as in so many others, the creation of new species on the characters of a single specimen should be strongly deprecated.

Family Gorgoniidæ.

This family is not well represented in the Indian Ocean, many of the genera which are very abundant and rich in species on the east and western shores of tropical America being entirely absent.

Several species from East African shores which were previously referred to the genus *Gorgonia* must now be transferred to other genera For example, *Gorgonia flammea* (E. & S.), *G. crista* (Möbius) and *G. pinnata* (L.) are now included in the genus *Lophogorgia*. *G. albicans* (Hickson) probably belongs to the genus *Eunicella*. The interesting viviparous species *G. capensis* (Hickson) is better placed in the genus *Leptogorgia*.

There are no known species of *Gorgonia*, as that genus is defined in modern classifications (see Hickson, 1930, p. 248), in any part of the Indian Ocean.

The two genera *Lophogorgia* and *Leptogorgia*, which seem to be common on the western coasts of S. Africa, have crept round the Cape to become established on the east coast, but have not spread further into the Indian Ocean itself.

Two species of Gorgoniidæ from S. Africa which were originally referred to the genus *Eugorgia* (*E. gilchristi* and *E. lineata*) do not agree with the description of that genus given by Bielschowsky (1929, p. 170). All the other species are inhabitants of the seas off the western shores of America from S. California to Peru.

An examination of my original preparations of *E. gilchristi* and of J. S. Thomson's excellent account of both species (1916, p. 38) proves that they should be removed from the genus *Eugorgia* and be constituted the species of a new genus, or referred to the genus *Leptogorgia*. Neither of them are related to the genus *Stenogorgia* as Bielschowsky suggests (p. 185).

The genus *Stenogorgia* has a much wider range in the Indian Ocean than any of the other Gorgoniidæ, extending from S. Africa to the Nicobar Archipelago.

Genus *Stenogorgia* Verrill (1883, p. 29).

The genus *Stenogorgia* is usually included in the family Gorgoniidæ because its axis is black, horny and devoid of any calcareous deposits, but it differs from other genera of the family in its large polyps protected by prominent conical verrucæ and its large or very large spindle-shaped spicules with scattered simple tubercles.

The large fleshy branches of some specimens give them a superficial resemblance to species belonging to other families. Even Kükenthal was mistaken in the first draft of his great " Valdivia " monograph (1919), when he gave the name *Ellisella africana* to his new species of *Stenogorgia*, a name which persists, as a misprint, in his pl. xxxiii.

It seems probable that when this genus is further investigated the differences between it and other members of the family will be emphasized.

The type species *S. costa* was dredged in 617 metres off Cape Fear on the east coast of N. America and was well described by Verrill (1883, p. 30), and apart from those from the Indian Ocean mentioned above, other species which have been referred to the genus are *S. miniata* from the Antilles, *S. rosea* from the coasts of Sweden and Norway, *S. africana* from the mouth of the Congo, *S. studeri* and *S. miniata* from the Malay Archipelago.

The genus, therefore, seems to have a very wide geographical distribution in deep or very deep water.

I have great pleasure in naming the new species described below after Lt.-Col. Sewell, the leader of the Murray Expedition.

Stenogorgia sewelli n. sp. (Pl. I, figs. 3 and 4.)

There are three examples of this species in the collection, one from the coast of Hadramaut in 95 metres, one from the Pemba Channel in 90 metres, and a fragment from 37 metres off Cape Guardafui.

A very small specimen only 10 mm. in height, attached to a shell, which may belong to the same species, was found at the great depth of 1415 metres off the coast of Hadramaut.

There are certain differences in appearance between the first two specimens and, consequently, it is advisable to describe them separately.

Specimen A. (Pl. I, fig. 3.)

Station 43, 95 metres, off the coast of Hadramaut. The specimen is complete with a small but broken disc of attachment. It is 120 mm. in height and 130 mm. in breadth. It branches freely in one plane to form a flabellum. There is an unbranched main stem, 25 mm. in length by 3 mm. in diameter, from which the cœnenchym is detached and the black axis fully exposed. At the upper end of this stem branches are given off irregularly right and left, and these give rise to secondary and tertiary branchlets.

There are no anastomoses.

The general appearance of the colony resembles very closely that of a specimen of *St. miniata* from the Nicobar Archipelago shown in Kükenthal's pl. xlviii, fig. 91 (1919).

The diameter of the largest branch at its base is 3 mm. and of the terminal branches about 1 mm.

Most of the polyps are bilateral in position and there are several irregularly disposed on both sides of the flabellum.

The verrucæ are conical in shape, about 2 mm. in height and situated at distances of about 2 mm. apart.

In many cases the base of the anthocodia protrudes from the aperture of the verruca and is conspicuous by its glistening white colour contrasting with the red colour of the verruca.

At the end of the terminal branches there are two large divergent verrucæ and below them a very small one on each side, followed by others in an ascending series of sizes (Pl. I, fig. 3).

The spicules are all slender spindles provided with scattered, prominent, simple wart-like tubercles. There are no clubs or other varieties. The largest spindle in one of my preparations is 1·2 mm. in length and 0·15 mm. in diameter, and a rough average of several of the larger ones is 0·9 mm. The calyx can be clearly seen on many of the protruding anthocodiæ. It consists of a thick band of slender spindles forming the crown and eight points composed of similar spicules crowded together.

The colour of the cœnenchym and verrucæ is bright red, but the anthocodiæ are pure white.

The specimen was collected on October 28th. No gonads were observed in any of the polyps.

Specimen B. (Pl. I, fig. 4.)

Station 111, 73–165 metres, Pemba Channel.

This specimen differs from Specimen A in its thick branches, very large verrucæ and sparse ramification.

It is 210 mm. in height and bears only three branches arranged in the same plane. There is no base of attachment, and therefore it may represent only a portion of a very much larger colony.

The thickest part of what seems to be the main stem is 5·5 mm. in diameter between the verrucæ. The diameter of the main branches is 3·4 mm. at the base and 2·5 mm. at their extremities. The average height of the verrucæ is 4 mm., and from the apices of many of them the pure white anthocodiæ project for another 2 mm.

The spicules of the cœnenchym are similar to those of Variety A but considerably

larger, the average dimensions of about twenty large spicules in a preparation being 1·5 by 0·3 mm., and the largest over 2 mm. in length.

The colour is red and, as in Variety A, the anthocodiæ are pure white.

There were small female gonads in all the polyps examined. The largest ova were 0·2 mm. in diameter. The specimen was collected on January 14th.

The fragment from Station 27, off Cape Guardafui, in 37 metres, is a terminal branch of a specimen which may have been similar to Specimen A. It is about 80 mm. in length and bears five branchlets of various lengths. The spicules are similar to those of the other varieties, but the largest one in my preparation is only 0·7 mm. in length. The colour of the specimen is a brighter red than those from deeper water, and the protruding anthocodiæ are pale yellow. The geographical position of this specimen is about half-way between those from which the other two specimens came.

Notwithstanding the differences between these specimens in the degree of ramification and in the thickness of the branches, there can be no doubt that they belong to the same species. In the very large size of the spindles of the cœnenchym, the structure of the calyx and in the absence of clubs or other varieties of spicules, as well as in colour, they are identical.

It is true that the flabellum of Specimen A is very similar to that of an example of *Stenogorgia miniata* from the Nicobar Archipelago, as described and photographed by Kükenthal (1919, p. 643) ; but the spindles are not only much smaller (0·3 mm.) but quite different in tuberculation to those of *St. Sewelli*. Moreover, *St. miniata*, according to this account, bears clubs and short girdled rods, as well as spindles.

In *Stenogorgia ceylonensis*, from Trincomalee, as described by Thomson and Henderson (1905, p. 310), the spindles are much smaller (0·5 mm.) and much more densely tuberculated than in *St. sewelli*.

Stenogorgia africana, from 44 metres off the mouth of the Congo, was fully described and illustrated by Kükenthal (1919, p. 644).

In many respects it seems to be closely related to *St. sewelli*, but all the many specimens he examined were unbranched. The only spicules of the cœnenchym that are mentioned are spindles which attain to a size of 0·45 mm. in length.

The height of the verrucæ was only 1 mm., about one-quarter of the size of the verrucæ of Specimen A of *St. sewelli*, and no part of the anthocodiæ protrude from the apertures. These characters may be due, to some extent, to the greater degree of contraction in the " Valdivia " specimens.

Family Muriceidæ.

Genus *Bebryce* Philippi (1842, p. 35).

The first description of this genus was by Philippi in 1842, and the first drawings of the spicules of the genus were by Kölliker (1865, pl. viii, figs. 1–3). The type-specimen came from deep water off Naples.

It is upon the characters of the spicules that the identification of the species must very largely depend ; and therefore I have made a very careful examination of these structures in some specimens from the Naples type collection, very kindly sent to me by Dr. R. Dohrn.

In every general preparation spicules of various kinds may be seen, but the most

characteristic forms are those which are situated at the surface of the cœnenchym and verrucæ. The others will be referred to later.

There seem to be two kinds of these surface spicules (Text-fig. 5), some in the form of an ancient chalice or wine cup and others like a starfish in outline. The former may be only younger stages in the development of the latter. The chalice forms (*cf.* Kölliker's fig. 2 and Text-fig. 5, A of this memoir) consist of an upper expanded part representing the bowl of the cup, a short, smooth stem and an expanded base. The edge of the cup bears a variable number of short processes which, in some cases, are ornamented with tubercles. The base also bears a few tuberculated processes. These chalices are about 0·1 mm. in height. The starfish or stellate forms (Text-fig. 5, B) bear 5–8 tuberculated arms and are about 0·2 mm. in expanse from the tip of one arm to that of another on the opposite side of the star.

At the centre of the star a prominent knob is frequently seen, not unlike the boss of a shield, but when this is carefully focussed it is found to consist of a short stem and swollen, tubercular extremity. As these spicules are usually arranged in a preparation

TEXT-FIG. 5.—*Bebryce mollis*. A, A "chalice" spicule; B, a "star" spicule. × 200 diams. From a specimen in the type collection at Naples.

with the star-like expansions flat on the glass the true form of the spicule is difficult to see. It is that of a chalice with a widely-expanded cup and a small stem and base. It is better observed in a small heap of dry spicules in which some of them may be seen sideways.

There are many variations in the size, degree of tuberculation, and in the number of processes of the cup and of the base in both these types, but strictly intermediate forms are rare.

The other spicules of the ordinary preparations, the thin, bent spindles of the calyx and the spindles, crosses, twins and quadruplets of the inner layers of cœnenchym, are often seen in other genera of Gorgonacea and are of minor importance for systematic purposes.

The other characters that have been described for the Mediterranean *Bebryce* may be found in the writings of previous authors, but some comment is necessary, based on investigations of the specimens of *B. mollis* in the Murray collection.

In the eighteen specimens from Station 157 the maximum height is about 100 mm., that is to say no really large ones were found; they were all either unbranched or slightly branched, the branches being in one plane without any anastomoses, and the colour dark brown. In these respects they agree with the specimens sent to me from Naples. As regards the thickness of the branches, the size and arrangement of the verrucæ on the

branches there is so much variation that these characters are useless for the purpose of a definition of the genus or species.

Thomson and Simpson recognized four Indian Ocean species of *Bebryce* in addition to *B. mollis*. These are *B. hicksoni*, *B. indica*, *B. tenuis* and *B. acanthoides*. The descriptions of the first three of these species prove that they are certainly not identical with *B. mollis*, but the spicule characters are so different from those of the genotype that there seems no good reason to refer them to the genus *Bebryce* at all.

I have been able to examine some examples of the species called *B. acanthoides* by Thomson and Russell (1909, p. 151). They were dredged in 91–142 metres off Providence Island, north of Madagascar. They bear no spicules similar to the chalices and stars of *Bebryce* and the surface of the cœnenchym is protected by thick, warty spindles, 0·2 mm. by 0·1 mm. in size, and numerous spheres 0·17 mm. in diameter. This species, therefore, should not be referred to the genus *Bebryce*.

I have re-examined my preparations of the *Bebryce* sp. ? from South Nilandu (1903, p. 813) and can now definitely assign it to *B. mollis*.

Kükenthal (1919, p. 841) has removed all the species formerly referred to the genus *Bebryce*, except *B. mollis*, to form a new genus, *Pseudobebryce*, and has therefore restricted the distribution of *Bebryce* to the Mediterranean Sea, the Azores and " Seinesbank ". Thomson and Dean (1931, p. 205) say that they cannot for a moment accept the separation of *Pseudobebryce* from *Bebryce*, and Aurivillius also (1931, p. 189) did not accept Kükenthal's new genus. Kükenthal was certainly in error in referring all the Indian and Pacific Ocean species to *Pseudobebryce* because, when specimens and spicule preparations of *Bebryce mollis* from Naples and the specimens from Station 157 are compared, side by side, there can be no doubt of their generic identity. Moreover, the fragment I described as *Bebryce* sp. ? (1903, p. 813) from the Maldives undoubtedly belongs to the same species.

Studer (1889, p. 10) gave a very good description of a specimen from 89 metres in the Arafura Sea which he called *Bebryce philippi*. It was larger than any of the specimens from the Maldives, but, as Thomson and Simpson maintain, it is identical with *B. mollis*.

It may be noted here that Miss Deichmann (1936, p. 125) has recently described three new species from the West Indies which are correctly referred to the genus *Bebryce*.

The question whether the four species from the Indian Ocean described by Sir Arthur Thomson and his partners (*vide supra*) are correctly referred to *Bebryce*, depends upon the definition of that genus which is accepted.

If it is agreed that the presence at the surface of the ectoderm of the chalices and stars are the essential characters of the genus, they certainly do not.

If, on the other hand, this view is not accepted, then the genus is very difficult to define.

In my view Kükenthal's definition of the genus (1924, p. 208) in so far as it insists on this character of the spicules, is scientifically most convenient and should be accepted.

To include all Thomson's species in a new genus " *Pseudobebryce* ", as Kükenthal does, is not satisfactory.

A re-examination of the type-specimens of these species is necessary before a definite solution can be found for the problem of their correct position in our system of classification, but most probably they should not be included under one common generic name.

Bebryce mollis Philippi.

Specimens belonging to this species were obtained from three stations, namely: Station 157, 229 metres, Maldives; Station 24, 73–220 metres, off Cape Guardafui; and Station 10, 55 metres, in the Red Sea.

In the collection from the Maldives there are eighteen specimens complete with the base of attachment, and several fragments.

They are of various sizes up to a maximum height of 100 mm. and a width of 60 mm. when the branches are spread out.

Several specimens are quite unbranched, but others show a few simple branches arranged in one plane. There are no anastomoses of the branches.

They are attached at the base either to solitary corals (*e.g. Paracyathus conceptus*) or to stones. The collection is of great interest because it shows the great variation of specimens living in the same locality as regards certain characters, such as their ramification and the size and distribution of the verrucæ, which are sometimes used for making specific distinctions.

Some of the specimens have thick (5 mm. in diameter) branches with large verrucæ crowded together on all sides, others have slender branches (2 mm. in diameter) with sparsely distributed and relatively small verrucæ, which may be either bilaterally arranged or irregularly scattered.

The characteristic spicules, the chalices and stars are almost exactly the same as those of the Naples specimens.

One specimen examined contained small ova (0·15 mm. in diameter). It was collected on April 6th.

The two small fragments from Cape Guardafui have exactly the same spicules, and undoubtedly belong to the same species as the specimens from the Maldives.

There is a small specimen from a depth of 55 metres at the southern end of the Red Sea which differs in some respects from the others, and might be regarded as a new variety (var. *ethiopeæ*). It is 60 mm. in height and the main stem gives rise to two secondary branches from which spring numerous terminal branchlets all in one plane. The branches are slender and the verrucæ comparatively small and most arranged bilaterally.

There are no anastomoses.

The colony is apparently complete as there is a small disc of attachment torn from some calcareous substance.

The spicules, however, are not exactly the same as those of the type species. There are chalices and stars, but both forms are decidedly smaller than in the types, the former having an average height of about 0·08 mm. and the latter a diameter of 0·15 mm. The stars bear much shorter and more numerous (14–15) tubercular marginal processes, and together form a close-set armour-plating at the surface of the cœnenchym.

This interesting specimen was found in shallower water than any of the others and, in my opinion, the difference observed in these spicules may be only adaptations due to the shallower water and, perhaps, other environmental conditions in the Red Sea. Other specimens from that region may prove that it is a representative of a new species but for the present it is better to regard it as a variety of *B. mollis*.

Echinomuricea andamanensis Thomson and Simpson (1909, p. 203).

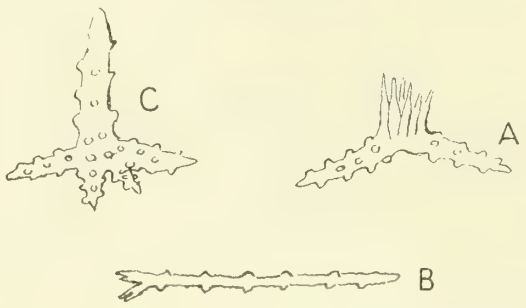
There are two complete specimens, measuring 100 mm. in height and 120 mm. in breadth and 60 mm. height by 50 mm. breadth, respectively, and three fragments of the flabella in the collection from Station 43, 95 metres, off the coast of Hadramaut.

The branching is irregular but entirely in one plane. In the larger complete specimen there are a few anastomoses, in the smaller one there are none. A few anastomoses occur on some of the fragments.

The thickest part of the main stem is only 2 mm. in diameter. The diameter of the terminal branches is about 0·6 mm.

The verrucæ are arranged all round the branches at distances of 0·5–1·0 mm. apart. They are almost cylindrical in form, 0·6 mm. high and 0·6 mm. broad.

The surface of the cœnenchym is covered with spicules from which protrude various sharp thorny processes. On the verrucæ, and particularly at their margins, these projecting processes are longer and more dagger-like. It seems to be a character of this



Text-fig. 6.—*Echinomuricea andamanensis.* A, A spicule from the surface of the cœnenchym; B, from the lower layers of the cœnenchym; and C, from the margin of the verrucæ. × 200 diams.

species that the spines of these marginal spicules are not so prominent as they are in other species of the genus.

The spicules at the surface of the cœnenchym are very variable in form (Text-fig. 6, A). They all show long spreading tuberculated roots varying from two to four in number and, springing from the centre of this group of roots, there is a tuft of small sharp thorns about 0·05 mm. in length, which protrude through the surface of the cœnenchym. The roots are very variable in length, but their total span is about 0·2 mm. It is noteworthy that in all my preparations I have not found one with a thin plate-like expansion in place of the group of thorns, such as we find in abundance in Acamptogorgia.

Beneath the surface and lying close to the axis there are several very irregular, straight or bent spindles up to 0·4 mm. in length and 0·05 mm. in breadth (Text-fig. 6, B).

On the verrucæ and particularly at their margins the groups of thorns are replaced by a single dagger-like spine, which varies in length from 0·1–0·2 mm. in length (Text-fig. 4, C). These spines are not quite smooth but show a few rounded tubercles near their bases (Text-fig. 6, C).

The roots of these spicules are similar to those of the spicules of the cœnenchym.

The calyx (operculum) can be clearly seen protruding from the verruca of several polyps. It consists of a crown of one row of thin bent spindles and eight points, each bearing a pair of almost parallel slender spindles slightly bent at their proximal ends.

All the spicules are colourless.

The colour of the colony is pale brown.

There is great difficulty in determining the species of this genus. No less than ten species have been described from the Indian Ocean alone and in addition to these, three species, *A. gracilis* and *A. rubra* Thomson (1905, pp. 177, 178) and *A. horrida* Hickson (1903, p. 814), previously referred to the genus *Acamptogorgia*, are most probably species of *Echinomuricea*.

The genera *Echinomuricea* and *Acamptogorgia** are closely related in some respects; but a reference to the type specimens in the "Challenger" collection shows that they may be fairly regarded as generically distinct.

I have examined spicule preparations of the types of *Acamptogorgia arbuscula* and *A. alternans* and in both these species the thin plate-like expansions on the upper side of the cœnenchym spicules are clearly seen. Some good drawings of these spicules were published by Wright and Studer (1889, figs. 4 and 5). I can find no such plate-like expansions in any species of *Echinomuricea* that I have examined.

Another distinction between the two genera is that in *Echinomuricea* the margin of the verruca bears spicules with long dagger-like projections which usually provide a ring of prominent protective spines for the retracted anthocodiæ.

Most of the Indian Ocean species of this genus have been described from single specimens. We have consequently no information as to the degree of variation that may be present, and until a large number of specimens from a single locality have been examined the reference of any specimen to a previously described species must be regarded as only provisional.

With some hesitation, therefore, I have referred the specimens in the John Murray Expedition collection to Thomson and Simpson's species *E. andamanensis*. They agree with that species in colour, in the small number of the anastomoses, in the short spines of the spicules on the margin of the verrucæ, and in the presence of a few tubercles on these spines.

It is possible that they are only young forms of *E. reticulata* of the same authors (*l. c.*, p. 206), which is much larger, bears many more anastomoses, and has smooth spines.

Both these species came from the Andaman Islands, but in neither case is the depth of the locality mentioned.

Another species which has a wide distribution, occurring in the Torres Straits, Malay Archipelago, Singapore and Ceylon, of which I have examined several specimens, is clearly a distinct species. This species is *Echinomuricea indo-malaccensis* Ridley.

Genus *Menacella* Gray (1870, p. 406).

There is no satisfactory modern definition of this genus. In Gray's original statement the most important characters are that the bark is "very thin and formed of numerous very slender fusiform spicules in bundles placed in different directions. Polype cells short, cylindrical covered with spicules like the bark, with a smooth eight-rayed lid."

Ridley (1882, p. 191) re-examined Gray's type specimen and described the spicules

* Kükenthal (1924, p. 192) changed the name *Acamptogorgia* to *Perisceles*, but, as pointed out by Wright and Studer (1889, p. lv), the generic name *Perisceles* was already occupied for a genus of Coleoptera. *Acamptogorgia* must therefore stand.

as " simple tuberculate fusiform spindles with strongly micro-tuberculate or exfoliating tubercles ". And he adds that " the largest measure 0·5 mm. by 0·10 mm."

Kükenthal (1924, p. 147) says that the tubercles of the spindles are " fein gezacht oder blattartig verbreitert ", and that the " operculum " is formed by three spindles arranged in a triangle with a base composed of a ring of thin spindles.

I can find no reference in any of Kükenthal's numerous papers which show that he made original observations on the genus and, therefore, it seems probable that his description of the " operculum " was derived from the description by Nutting (1910*a*, p. 47) of some specimens from Bali which he identified as *Menacella reticularis*. Unfortunately, Nutting's account of this species was not illustrated by any figures, and the size of the spicules was not mentioned. There may be some hesitation in accepting Nutting's identification of the Bali specimens as correct ; but even if it is, there is no reason for accepting his description of the operculum as a character of the genus.

Kükenthal's account of the tubercles of some of the spicules as being leaf-like (blattartig) seems to be due to his interpretation of Ridley's very vague expression " exfoliating ". I have examined a preparation of the spicules of Gray's type of *Menacella reticularis* and could find none of them with leaf-like tubercles.

The characteristic features of the genus are : (1) the eight triangular flaps of the upper end of the verrucæ, forming the operculum of some authors, but not to be confounded with the calyx of other genera ; (2) the spindle-shaped and oval spicules with densely crowded tubercles which, without being arranged in any definite order, form a protective crust for the cœnenchym and verrucæ.

Menacella reticularis Gray (1870, p. 406).

There is one example of this species in the collection from Station 151, off the Maldive Archipelago, at a depth of 101 metres.

The base of attachment is missing, but the specimen is otherwise complete. It is fan-shaped, but the branches are not quite in one plane. It is 100 mm. in height and 120 mm. in breadth. The thickest part of the main stem is 4 mm. in diameter. It bends in a curve to one side and all the secondary branches spring from its convexity. This is an unusual method of branching in the flabelliform Gorgonacea and seems to be a characteristic feature of the species.

There are no anastomoses.

The polyps are mainly bilateral in position and, in the partially retracted condition, are approximately 0·6 mm. in length and the same in diameter.

The colour is dark brown.

The spicules are in the form of spindles and clubs bearing numerous densely crowded tubercles which are not arranged in definite whorls. These tubercles are usually short cylindrical processes about 0·005 mm. in height, expanding a little at the distal end, to end in a crown of very minute knobs. It is not quite clear what Ridley meant by the expression " exfoliating " as applied to these tubercles ; but there are none in my preparations which show leaf-like expansions.

The size of the largest of these spicules is 0·2 mm. by 0·04 mm. In the examination of several hundreds of spicules spread out on a slide I found a few that are slightly larger

than this and, of course, several that are much smaller, but the figures given above represent the size of most of the full-grown spicules. The verrucæ are armed with densely crowded spicules of approximately the same size as those of the general cœnenchym, and there is no definite arrangement of these spicules in rows or in any other pattern.

At the distal end of the verrucæ there are eight triangular lobes, forming the "lid" of Gray and the "operculum" of other authors.

In the description of the type of this species no locality is given, but on the slide of the spicule preparation the words "British Columbia" are written.

This locality, however, cannot be trusted. I have examined collections of Alcyonaria from various localities off the west coast of North America, including British Columbia, and have seen no examples of species of this genus.

According to Nutting (1910, p. 46) the species occurs in the Bali Sea, and Thomson and Dean (1931, p. 198) record fragments of it from a locality off Misol Island, also in the Malay Archipelago.

The specimen described above differs from the type in the size of the spicules, which are, according to Ridley's statement, 0·5 mm. in length, and 0·4 mm. according to my own measurement of the spicules of the type specimen. In the Maldive specimen they are only 0·2 mm. in length.

Nutting (1910*a*, p. 46) says the colony of his specimen "is unilateral, most of the branches being on one side of the main stem", as it is in the Maldive specimen.

No statement is made by Gray or Ridley to show that the type specimen had the same peculiarity of colony formation, and it is, therefore, impossible to say that this is a good specific character.

It is unfortunate that neither Nutting nor Thomson and Dean mention the size of the spicules of the Malayan specimens, nor gave a figure of them, nor do they record the presence of clubs in their preparations.

In conclusion, it seems to me better to retain the name *M. reticularis* for the Murray Expedition specimen rather than invent a new name on the characters of a single specimen.

Menacella sladeni Thomson and Russell (1910, p. 150). (Pl. I, fig. 5.)

Station 157, 229 metres, Maldives.

There are two specimens from this locality which present a problem of unusual interest and difficulty, but I have decided to refer them to the species *Menacella sladeni*.

One of the specimens is 150 mm. in height and about 90 mm. in width. It was attached at its base to a *Paracyathus conceptus* (Gardiner and Waugh, 1938, p. 184). The other was only a branch of another specimen and is 100 mm. in length.

The ramification is sparse and the branches are arranged definitely in one plane without any anastomoses (Pl. I, fig. 5).

The diameter of the main stem of the larger specimen is 4 mm. and of the terminal branches 3 mm. The larger branches are distinctly flattened and the polyps mainly bilateral in position, but at their terminal extremities they become round in section and the polyps are more irregularly scattered.

The larger verrucæ are crater-like cones about 0·8 mm. in height, 1·5 mm. in diameter at the base and 0·9 mm. in diameter at the top.

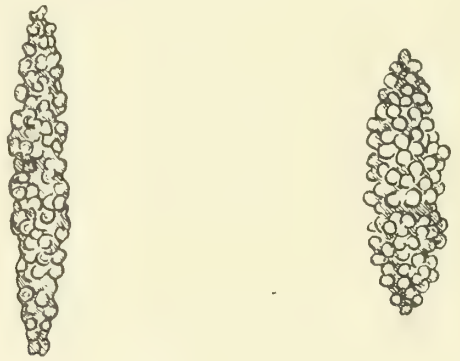
In the centre there is a deep pit in which are the shrivelled remains of the anthocodiæ. It is probable that the specimens were either dead or moribund when captured.

The verrucæ terminate above in eight triangular flaps bent over but not covering the crater-like aperture. The spicules at the surface of these flaps do not differ from those of the general surface of the cœnenchym, and are not definitely arranged in lines. The cœnenchym is moderately thick, *i. e.* in a branch 3 mm. in diameter the axis is 2 mm. and the cœnenchym about 0·5 mm. thick. It is not layered, but there are 6–8 spicules irregularly arranged in a line drawn vertically from the surface to the axis.

The general surface of the cœnenchym and verrucæ is granular in appearance due to the presence of numerous small spicules, which are not arranged in definite rows nor form any other pattern.

The spicules (Text-fig. 7) at the surface of the cœnenchym vary in outline from thick spindles 0·23 mm. by 0·05 mm. in size to stout oval forms 0·23 mm. by 0·07 mm. in size, with numerous intermediates.

In the deep layers of the cœnenchym near the base of the main stem the spicules are slightly larger than this. The difference is hardly noticeable, but as a result of numerous



Text-fig. 7.—*Menacella sladeni.* Spicules of the general cœnenchym. × 200 diams.

measurements it may be said that the length of the largest spindles at the surface rarely exceeds 0·26 mm., whereas in the deep layers at the base of the colony the length is often 0·3 mm.

In all the spicules the tubercles are short, stout knobs, sometimes flattened at the top and very densely crowded together. There are no spicules with exfoliating tubercles nor any in which the tubercles are arranged in whorls.

The large specimen, collected on April 6th, bore numerous gonads up to 0·14 mm. in diameter.

The type specimen of *Menacella sladeni* is in the British Museum. It is 30 mm. in height and may be only a small fragment of a much larger colony. It has only a few branches, and these are about 2 mm. in diameter.

It was dredged in 46 metres off Providence Island, between Madagascar and the Seychelles.

As the type specimen, like the one described above, differs so remarkably in its sparse ramification and its thick branches from *M. reticularis*, some doubt has been felt as to whether it was correctly referred to the genus *Menacella*.

An examination of this specimen shows, however, that, as in *M. reticularis*, the verrucæ terminate above in eight triangular processes armed with spicules similar to those on the

verrucæ and the cœnenchym. Moreover, as the specimen is dry, the size, shape and tuberculation of the spicules can be clearly seen *in situ* and are found to be almost exactly similar in these respects to the spicules of the type of *M. reticularis*.

There is one important point in which I have been unable to confirm the original description of the species by Thomson and Russell. They say that " on the walls of the verrucæ there is a definite arrangement in eight double rows of small spicules *en chevron* ".

I have carefully examined every verruca on the type specimen and have not seen such a definite arrangement of the spicules on any of them. In every case the spicules on the verrucæ are of the same type as those on the cœnenchym and quite irregularly scattered.

It is this point that Kükenthal (1924, p. 147) seized upon when he said that *M. sladeni* does not belong to the genus *Menacella* : " weil die Kelchskleriten in acht konvergierenden Doppelreihen angeordnet sind."

Genus *Paracis* Kükenthal (1919, p. 837).

There is considerable confusion in the literature of the subject as to the characters which distinguish *Acis* from *Thesea*, and also as a result of the proposal to abandon the generic name *Acis* and substitute for it the names *Scleracis* for most of the West Indian species and *Paracis* for the Indian Ocean species. Miss Deichmann (1936) has recently examined the type specimens of *Acis* (*Scleracis*) *guadaloupensis* and a large number of specimens belonging to the same species from various localities in the West Indies and the coast of Florida. She has also examined the type specimen of *Thesea guadaloupensis* (D. and M).

Kükenthal (1924, p. 153) has, most unfortunately, referred Duchassaing and Michelotti's type species *Acis guadaloupensis* to the genus *Thesea*, so that according to his system this species disappears from the genus *Acis* altogether.

Two important conclusions can be drawn from the study of Miss Deichmann's paper. In the first place, that the cœnenchym of the type species of *Thesea* has two layers and that, therefore, the distinguishing character which, according to Kükenthal (1924, p. 140), separates *Thesea* from *Scleracis* and *Paracis* is unsound ; and secondly, that it is very doubtful if the West Indian species of *Acis* (*Scleracis*) are generically distinct from the Indian Ocean species (*Paracis*) (Deichmann, p. 108).

The character given by Kükenthal (1924, p. 140) to distinguish *Scleracis* from *Paracis*, namely, that in the former genus the polyps are situated laterally on the branches and in the latter that they are not, cannot, in the light of Deichmann's investigations, be accepted as sound.

The best plan now would be to return to a simpler classification, to restore the genus *Acis*, to abolish *Scleracis* and *Paracis*, and to regard *Acis* as a genus, which like *Leptogorgia* and *Iciligorgia*, has a distribution both in the West Indies and eastern oceans (see Hickson, 1938, p. 594). But, unfortunately, the name *Acis*, given to this Muriceid by Duchassaing and Michelotti in 1860 was preoccupied by Billberg for a Coleopteran in 1823 and therefore *Paracis* (Kükenthal, 1919, p. 837), having page preference over *Scleracis*, must be the name of the combined genera.

A satisfactory distinction between the genera *Paracis* and *Thesea* has still to be found. In Deichmann's key index (1936, p. 99) *Scleracis* is distinguished from *Thesea* by the spicules of the outer layer being " glass-like, transparent, as large spindles or plates " ;

whereas in *Thesea* these spicules are "not glass-like, nor transparent; as grains, plates or spindles". This does not seem to me a satisfactory definition for any genus, because the transparency of these white spicules is a very variable character. In *Paracis orientalis* and in the type of *Thesea guadaloupensis* there is no appreciable difference in the transparency of the spicules.

In the specimen of *Paracis orientalis* described below and in the type of the same species a very striking feature is the presence of long spines on the spicules at the margin of the verrucæ. No such spicules are found in my preparation of the spicules of *Thesea guadaloupensis*.

Are such spicules found in the West Indian species referred to the genus *Scleracis*? No definite answer can be given to this question at present; but Riess (1929, p. 406) in her elaborate account of *Scleracis pumila* says: "Acht konvergierenden Doppelreihen von Spindeln bilden ausserdem am Kelchrand oft vorragende Spitzen." No such spicules, however, have been figured for the West Indian species.

Paracis (*Acis*) *orientalis* Ridley (1882, p. 126).

The only specimen of this genus in the collection was found at Station 24, 73–220 metres, off Cape Guardafui.

It is a small specimen, 40 mm. in height by 40 mm. in breadth. It is in the form of a perfect little fan, with few branches without anastomoses, and with a small disc of attachment.

The polyps are situated on all sides of the branches and are represented by verrucæ in various stages of contraction, the largest being about 1·3 mm. in height and 1 mm. in diameter.

The surface of the cœnenchym is armoured with numerous flattened scales of very variable size and shape, but all densely tuberculate with small compound tubercles. Most of these scales are spindle-shaped and reach an average length of about 1 mm. by about 0·5 mm. in greatest breadth, but there are various other shapes and sizes fitting into spaces between the spindles. There is no appreciable difference between the size of the tubercles of these spicules and that of the spicules of the type. Beneath this outer layer there is an inner layer of smaller spindles.

The verrucæ have a very ragged appearance, due to distortion in contraction.

They are armed for the greater part of their length by longitudinally-arranged spindles similar to but smaller than those of the cœnenchym, but at the upper margin there is a row of scales armed with one, two or three long projecting spines. These spicules are extraordinarily variable in form and in the number and size of the projecting spines (Text-fig. 8).

The calyx is, in most cases, completely hidden in the verrucæ, but where it can be seen it consists of a crown of rings of horizontal spindles and eight points, each bearing two bent spindles. The exact number of rings in the crown could not be determined as they were never fully exposed, but the number must be three or more.

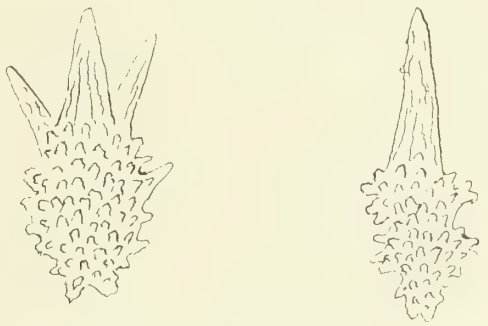
The colour of the colony is pale brown, but the spicules are all white.

The first species of *Acis* to be described from the Indian Ocean was *A. orientalis*. It was founded on three specimens from 80 fathoms (146 metres) of water off Mauritius, and was fully described and figured by Ridley. I have examined a branch of one of these

specimens and some preparations of its spicules and can find no difference of any specific importance between this type and the single specimen from Cape Guardafui.

Since Ridley's paper was published no less than nine new species have been described from the Indian Ocean by Thomson and Henderson (1905), Thomson and Simpson (1909), and Thomson and Russell (1910). Of these species *Paracis ceylonensis* seems to be widely distributed in this ocean and, as several specimens were examined, a considerable amount of variation in the manner of branching was recorded (Thomson and Simpson, p. 232). Most of the other species were based on the examination of one or two specimens only. Thomson and Russell (p. 157) give a key for the identification of the species of *Acis*, according to which the difference between *Acis ceylonensis* and *A. orientalis* is that in the former the spicules are " round and pebbly ", and in the latter they bear " large tubercles ".

This is a very unsatisfactory distinction bearing in mind the wide range in variation in the spicules of the type of *A. orientalis*. It seems probable, therefore, that *A. ceylonensis* is little more than a variety of the older species.



Text-fig. 8.—*Paracis orientalis*. Two examples of the spicules at the margin of the verrucæ. × 50 diams.

Genus *Versluysia* Nutting (1910*a*, p. 35).

Nutting did not give very clear reasons for separating this genus from *Muricella*. On consulting his key index of the genera of the Muriceidæ on his pages 9–10, *Versluysia* is found to be included among the genera in which the " spicules are nowhere arranged *en chevron* ". In *Muricella*, on the other hand, the spicules are arranged " *en chevron* on the calyx-walls and tentacle-bases ".

He took as his genotype the species called *Muricella ceylonensis* by Thomson and Henderson (1905, p. 302), but also included in the genus *Muricella ramosa* of the same authors, p. 301.

In a later and more carefully considered paper by Thomson and Simpson (1909, p. 249) *M. ceylonensis* was merged with *M. ramosa*, and the latter name has page-priority for the combined species. In the description of *M. ramosa*, as thus reconstituted, these authors state distinctly that there is an " operculum " consisting of about eight spindles arranged *en chevron*.

Nutting's key index character does not apply to *Versluysia ramosa*.

There are, however, some wide differences between most of the older species of *Muricella*, such as *Muricella nitida* amd *M. tenera*, and some of the species from the Indian Ocean, which I have not had the opportunity to investigate fully, and it is possible that the retention of the genus *Versluysia* may yet be justified.

There is, however, a close relationship between *Muricella*, *Versluysia*, *Anthogorgia* and *Calicogorgia*, and it might be a great advantage if some of these ill-defined generic names of these Muriceidæ could be suppressed.

Versluysia ramosa Thomson and Henderson (1905, p. 301).

Versluysia ramosa, Nutting (1910*a*, p. 37).
Muricella ramosa, Thomson and Simpson (1909, p. 249).

Thomson and Simpson merged *Muricella ramosa* and *M. ceylonensis* to form one species, and there are three specimens in the Murray collection which agree with the description given by these authors of that species.

A specimen from Station 35, near Aden, 441 metres.

A large complete specimen, 280 mm. in height and 200 mm. in expanse, is in the form of a perfect flabellum.

The disc of attachment is 15 mm. and the main stem is 5 mm. in diameter. There is no cœnenchym left on the stem and main branches and only patches left on the secondary branches ; and therefore the jet-black axis is fully exposed over a great part of the colony. Anastomoses are scarce.

A specimen from Station 45, off coast of Hadramaut, 38 metres.

An incomplete colony, 120 mm. in height by 120 mm. in expanse, attached to a mass of coral conglomerate. Parts of the terminal branches are broken off. The main stem, 4 mm. in diameter, is formed by the fusion of two stems which rise from two attachments hidden in the conglomerate. The cœnenchym is much better preserved than in the specimen from Station 35, and covers most of the branches. There are very few anastomoses.

A specimen from Station 27, off Cape Guardafui, 37 metres.

This is incomplete, the main stem and disc of attachment being lost. It consists of a network of branches about 120 mm. in expanse. The branches are more delicate and the anastomoses far more frequent than in either of the other two specimens. The cœnenchym is well preserved.

Associated with this specimen were large numbers of the polychæte worm *Syllis* (*Haplosyllis*) *spongicola* Grube.

The specimens agree with the description of the species given by Thomson and Simpson (1909, pp. 249 and 253) in possessing a very thin cœnenchym through which the black axis can be seen, the small verrucæ and their irregular distribution on the branches, the general flabellar mode of branching and the presence of anastomoses. These authors examined a large number of specimens, including those of the Wood-Mason collection, and came to the conclusion that in many respects the species is very variable. The only point of difference appears to be that the spicules of the cœnenchym are smaller in the Murray specimens than in the types. After searching through many hundreds of spicules from all three specimens, the largest spindle I could find was only 1·5 mm. and there were very few over 0·7 mm. in length. Thomson and Simpson found some spindles 2·5 mm. and others 4 mm. in length. As this is a very variable character it is probably not of much importance.

The verrucæ are ragged in appearance, but roughly dome-shaped and about 1 mm. in breadth by 0·5 mm. in height.

The calices which form the so-called " operculum " consist of a crown of 4 or 5 rings of horizontal spindles and eight points of 6 or 8 spindles arranged irregularly *en chevron*.

The species has a wide distribution in the Indian Ocean, having been found in the Andaman Sea, off the west coast of Ceylon and in the Persian Gulf, as well as at the three localities given in this paper. The depth in which it occurs is, frequently, 70–90 metres, but there is one record of 441 metres given above.

Family Gorgonellidæ.

Gorgonella granulata ? Esper (1794–1806).

There are two fragments in the collection which may be referred provisionally to this species. They were dredged at Station 45, off the coast of Hadramaut, in 38 metres of water.

They are 70 and 55 mm., respectively, in height, and both of them are bright red in colour. They branch in one plane and there are no anastomoses.

The thickest branch is 5 mm. and the terminals uniformly 4 mm. in diameter, the latter with blunt extremities.

The polyps are situated all round the branches and are represented at the surface by low mounds, about 1 mm. in diameter, with a stellate aperture.

Spicules.—Nearly all the spicules in a preparation are double clubs with two to four distinct whorls of prominent tubercles. The average length of the largest spicules is 0·1 mm. In some of them the whorls are not so well pronounced, the tubercles being more unevenly distributed.

There are also a few small spheres and other types of spicules.

The form of the double clubs is very similar to the figure of a spicule of *Gorgonella pseudo-antipathes* given by Kölliker (1865, pl. xviii, fig. 42).

The axis of these fragments has a smooth surface and it is heavily calcified.

These fragments have a very close resemblance to the terminal branches of the specimen shown in Esper's pl. iv of *Gorgonia granulata*. Kölliker (pl. xviii, fig. 43) gave two figures of the spicules of this species, one of them of a double-club which has a close resemblance to the smaller spicules of the specimen described above, the other of a spindle which is represented in my preparations by a very few examples. Thomson and Simpson (1909, p. 274) resuscitated the species for a yellowish brown specimen from the Andaman Islands and a much battered specimen from the Wood-Mason collection of unknown habitat.

The double clubs of the Andaman specimen, however, have only one whorl of tubercles, and it bears several types of spicules that do not occur in the Murray specimens at all.

In Esper's plate several anastomoses of the older branches of the colony are clearly shown, but Thomson and Simpson state that in their specimen there was " no hint of anastomoses ". Toeplitz (1929, p. 366) referred the *G. granulata* of Thomson and Simpson to the species *G. miniacea* because it had no anastomoses, and Esper's species to *G. umbraculum* because it had anastomoses. If Toeplitz's classification is to be accepted, and the species of *Gorgonella* be determined arbitrarily on the presence or absence of anastomoses, the fragments from the coast of Arabia cannot be identified, because it is not known whether the whole colony, from which they were broken off, did or did not form a network in its main branches.

It is clear from these remarks that the classification of the species of *Gorgonella* is in a most unsatisfactory condition and that a thorough reinvestigation of all the available material is most desirable.

Meanwhile, it is better to refer the specimens described above to Esper's species, which they resemble very closely in form and colour, rather than burden the literature with a new species without an adequate description of a complete specimen.

Genus *Scirpearia* Cuvier (emend).

It is only necessary to say that I agree with Simpson (1910, p. 308) that *Scirpearia*, *Scirpearella* and *Ellisella* should be united into one genus, but I have pleaded already (1932, p. 504) for the retention of *Ctenocella* as a distinct genus.

Scirpearia furcata Hickson (1903, p. 822).

There is a complete specimen and some fragments of Alcyonaria which may be referred to this species from three localities in the collection.

(A) From Station 45, 38 metres, off the coast of Hadramaut. One complete specimen and two fragments.

(B) From Station 89, 193 metres, off Bombay. Two fragments.

(C) From Station 111, 73–165 metres, Pemba Channel. One incomplete specimen.

All the specimens are unbranched.

(A) This specimen, which appears to be complete, is 330 mm. long and has a diameter of 3 mm. for the greater part of its length, but tapers to a fine point at the distal extremity.

The polyps are tightly contracted, so that the verrucæ are almost flush with the surface of the cœnenchym. A deep, narrow groove is seen on both sides of the branches.

Attached to one of the fragments in the same tube there is a white mass of the Tunicate *Didemnun herdmani*.

The colour is brown.

(B) The two fragments are 70 mm. and 60 mm., respectively, in length and 1·5 mm. in diameter. The polyps appear to be very small as compared with those of the specimens, and the verrucæ are not prominent. They have a close resemblance to the figures of an example of this species given by Simpson (1910, pl. xiv, fig. 88) and, as in that specimen, there is a broad band which is not polyp-bearing on one aspect of the colony.

The colour is white.

There is a note in the tube that a specimen of *Scalpellum bengalensis* was attached to this Gorgonian.

(C) The single specimen from this locality is distinguished from the others by its very prominent verrucæ. It is about 210 mm. in length, and its diameter between the verrucæ is 1 mm. The verrucæ are conical in shape and about 1 mm. in height. There is a bare track, with a groove in some places, on one side of colony.

The colour is yellow.

The species *Sc. furcata* was the subject of an extremely valuable investigation by J. J. Simpson (1910, p. 339). He examined the types and co-types of this and other species, and also a very large number of specimens of the genus from various localities in the

Indian Ocean. Moreover, in order to check his results, he made a laborious examination of several regions of one large specimen from Providence Island.

By these means he was able to prove that there is considerable variation, not only in specimens from different localities, but also in the various parts of a single colony. It is evident, therefore, that many of the characters that have been used for the determination of the species of this genus are of little scientific value.

The specimen and fragments from three localities, collected by the Murray Expedition, seemed, at first sight, to belong to three distinct species, but after a careful study of Simpson's detailed description of *Scirpearia furcata* I am convinced that they are only variants of that species.

In 1929 (p. 289) Toeplitz published a revision of the genus which was incorporated into Kükenthal's account of the Gorgonaria in ' Das Tierreich ' (1924, p. 367).

In this classification *Scirpearia furcata* was transferred to the genus *Ellisella* and divided between the species *E. lævis* and *E. maculata.*

Toeplitz did not examine the type or co-types of *Scirpearia furcata* and probably had far less material from the Indian Ocean to investigate than Simpson had. He gave no reasons for his changes in the system, no criticism of Simpson's paper, and entirely ignored the probabilities of variation in his species.

For these reasons the paper by Simpson should be regarded as the standard work on the subject in preference to any other.

Nicella reticulata Thomson and Simpson (1909, p. 266). (Pl. I, fig. 1.)

Station 111, 73–165 metres, Pemba Channel.

A large number of specimens which may be attributed to this species were dredged at Station 111. They are all of great size, the largest, although not quite complete, is 215 mm. in height by 150 mm. in width. As there is no base of attachment on any of them, there is no evidence of the length of the main stem. The rest of the colony is strictly flabellate in growth and there are numerous anastomoses. The size of the meshes is very variable, but they are usually oblong in shape and about 40 mm. long by 10 mm. in breadth. All the branches are round in section and exhibit no shallow grooves on either side. They are about 5 mm. in diameter in the middle of the flabellum and the terminal branches taper to a fine-pointed extremity. The verrucæ are very numerous, scattered all round the branches, about 1 mm. in diameter and only slightly raised above the level of the cœnenchym.

The axis is brown in colour and, in the larger branches, scored at the surface by numerous fine, slightly spiral, longitudinal grooves. It is highly calcified.

Spicules.—The surface of the cœnenchym bears numerous very small double stars and capstans, which give it a very finely granular appearance when examined with a 1-inch objective. These spicules are about 0·03 mm. in length. Below the immediate surface a few small spindles make their appearance, and these increase in number and in size as the internal region is reached.

Most of these spindles are sharp-pointed and provided with 5–7 girdles of prominent tubercles. The largest of them are about 0·2 mm. in length.

A description of the calyx cannot be given as the polyps are very strongly contracted, and the specimens themselves show some signs of having been dead or moribund when

captured. Some preparations of the shrivelled polyps, however, show that there is a crown of slender, bent spindles and points of thicker bent spindles. All the spindles in these polyps show tubercles that are not so regularly arranged in girdles as are those of the cœnenchym.

The type specimens of this species were described by Thomson and Simpson, and came from the Persian Gulf in 88–89 metres, and from the Laccadives in 54–91 metres. Like the specimens described above, they were of great size, a typical colony measuring 270 mm. in height by 160 mm. in greatest breadth.

The specimens from Pemba Channel do not entirely agree with the description of the type. In many of the branches of the type the polyps are mainly arranged in two rows and the surface bears longitudinal furrows, which are sinuous and sometimes almost spirally twisted. Moreover, the small double star or capstan spicules are larger and the spindles are much smaller than in the Pemba specimens.

Most of Thomson and Simpson's specimens had a variable brick-red to vermilion colour, whereas the Murray specimens were uniformly pale brown and all the spicules were white.

Notwithstanding these divergences from the type, the Murray specimens should, in my opinion, be referred to this species.

The presence of longitudinal grooves on the branches does not seem to be a trustworthy character for making specific distinctions because it is very variable, even on a single specimen, and may be due to the activities of epizoic Crustacea.

If this identification is correct the species has a wide distribution in the Indian Ocean and seems to be abundant in some localities. It occurs in the Red Sea, the Persian Gulf, on the east coast of Africa and in the Laccadive Archipelago.

Nicella reticulata ? Thompson and Simpson (1909, p. 266).

There are two fragments of Gorgonellids in the collection which may be referred provisionally to this species.

One of them came from Station 10, 55 metres, in the Red Sea, which will be referred to as Specimen A ; and the other from Station 43, 95 metres, off the coast of Hadramaut, which will be referred to as Specimen B.

Specimen A : This colony is very lax in growth with very few anastomoses. The branches are slender and some of them are not in the plane of the flabellum. The size of the fragment is 60 mm. by 60 mm. The polyps are represented by low mound-like verrucæ and are situated unevenly all round the branches.

Most of the spicules in the preparations are long, pointed spindles 0·2–0·3 mm. in length, but there are several double clubs or capstans about 0·04 mm. in length.

Although these spicules resemble very closely those of the specimens from the Pemba Channel, the spindles are much more numerous and the double clubs are comparatively few in number.

The colour is very faintly pink.

Specimen B : This fragment, 50 mm. by 50 mm. in size, shows a much closer meshwork of anastomoses than Specimen A. The branches are also very slender and circular in section.

The verrucæ are prominent (0·4 mm. in height), conical in shape and irregularly distributed.

The colour is pale red.

The spicules of this specimen present a very different appearance to those of the other one. There are very few small double stars less than 0·07 mm. in length and I have found no spindles over 0·1 mm. in length. Most of the spicules in a preparation are small double clubs of various sizes up to a maximum of 0·1 mm. in length.

It may be considered doubtful if these two fragments should be referred to the species *Nicella reticulata*. The loosely-built flabellum of A and the pale red colour and prominent verrucæ of B give them a very different external appearance from the typical examples of this species and from one another.

They agree with *N. reticulata* in the presence of anastomoses and in a general resemblance between the two characteristic types of spicules. Specimen A is, in my opinion, undoubtedly a *Nicella reticulata*, and the difference between it and the Pemba Channel specimens may be correlated with some environmental conditions in the two localities, the closer meshwork of the anastomoses being often associated with stronger currents of water than more loosely-built flabella.

The position of specimen B is more doubtful. The small size of the spicules suggest that it is related to the genus *Gorgonella*, but in form they are unlike the spicules of any species of that genus I have examined.

It may be that this specimen is only a part of a very young specimen of a *Nicella* or possibly of a *Gorgonella*, but the difficulty of distinguishing small slender fragments of the two genera is almost insuperable and will be until a series of growth stages can be obtained.

Family Primnoidæ.

Stachyodes allmani Wright and Studer.

Calypterinus allmani W. and S., 1889, p. 53.

Station 158, 918 metres, Maldives. Station 159, 1280 metres, Maldives. Station 42, 1415 metres, Hadramaut.

A large jar was filled with numerous specimens and fragments from Station 159. The largest of those with the disc of attachment intact varied in height from 130–265 mm. with a maximum expanse of 120 mm. The branching is dichotomous and definitely in one plane. The number of branches varies considerably. One specimen, 170 mm. in height, has only one simple branch, but most of the complete specimens bear 15 to 20 terminal branches.

The main stem, for a distance of 20–30 mm. from the base of attachment, is 4 mm. or more in diameter and bears no cœnenchym in any of the specimens. The surface of the axis is marked by numerous ridges arranged with a slight spiral twist. The polyps are arranged in definite whorls 2 or 3 mm. apart. On the secondary and terminal branches the whorls are closer together than on the primary branches and usually bear 4 or 5 polyps as compared with 4 or 3 on the proximal parts of the colony.

The polyps vary considerably in size from a total length of 4 mm. on the primary branches to 3 or 2 mm. on the secondary or terminal branches. On the terminal branches the polyps have a distinct flexure downwards, *i. e.* towards the root. In the larger branches

this flexure is not so pronounced, and on some of the primaries the polyps stand out almost straight.

It is not necessary to give a detailed account of the scales of these polyps as they agree fully with those of the type as described and figured by Versluys (1906*a*, p. 93), but an examination shows clearly the large wing-like expansions of the basal scales and the spine on the median scales which constitute important characters of the species.

The axis consists of alternate laminæ of a horny substance and a granular calcareous deposit, so that on examining a number of axes from different branches some have a smooth iridescent, others a chalky, surface. On the main stem, however, the outermost layer of chalky substance is much thicker and more compact than on any of the branches, and its surface is scored by spiral ridges.

The fragments from the south coast of Arabia (Station 42) clearly belong to the same species.

The best account of this species is by Versluys (1906*a*, p. 92), who examined the type specimen and gave some accurate figures of the armature of the polyps.

According to this author two important features of the species are the wing-like, lateral expansions of the basal scales and a spine-like projection of variable length from the anterior border of the median scales. In these characters the specimens from the Maldives agree very closely with the type.

The locality for the type of this species given in the Report of the "Challenger" Expedition is "Fiji reefs", but as it is very improbable that it grew in shallow water, and as other gross mistakes in the localities of the "Challenger" specimens were made (see Hickson, 1937*a*, p. 97), it would be better to regard the habitat of this type as unknown.

Specimens named *S. allmani* have been recorded from other localities. Those collected by the "Caudan" Expedition in the Bay of Biscay, as shown by Versluys (1906*a*, p. 93), belong to quite a different species, and those collected by the "Prince of Monaco" in the Atlantic could not be referred to this species by Thomson (1927, p. 29) "without great hesitation".

The figures given by Thomson and Henderson (1906, pl. ii, fig. 4) of fragments of the species from the Laccadive Sea in 703 fathoms are satisfactory, although probably upside down.

The species is also recorded by Thomson and Russell (1909, p. 142) from deep water off Saya de Malha and Providence Island, but it should be noted that the base of attachment of their specimen, as described and figured, is quite distinct from that of any specimen in the Murray collection.

In conclusion it may be said that the only certain locality for this species is the seas round the Maldive and Laccadive Archipelagos at depths of 300–900 fathoms.

Thouarella flabellata Kükenthal (1919, p. 418).

Thouarella (*Euthouarella*) *flabellata* Kükenthal, 1924, p. 294.

Station 158, 914 metres; Station 159, 1280 metres; Maldives.

There are two large tubes containing examples of this species, one with a single specimen from Station 158, the other with two almost complete specimens and numerous fragments from Station 159.

The most perfect specimen is about 300 mm. in height. The base of attachment, from which the main stem rises, is covered with a thick coat of non-spicular calcareous substance. It consists of a spreading plate, partly broken away, but over 25 mm. in diameter, from the centre of which rises a thick bead-like swelling 5 mm. in diameter. In this bead the stem forks into two main branches which are themselves almost free from the chalky substance of the base.

There is an indication of a similar structure at the base of the type specimen shown in Kükenthal's beautiful photograph (1919, pl. lxii).

The two main branches each give rise to three or four long secondaries arranged proximately in one plane and these support numerous slender terminals arranged quite irregularly round the branches. These slender terminals are about 20 to 40 mm. in length.

In the processes of capture and preservation a great many of the polyps have become detached, leaving many of the terminal branchlets and parts of the main branches with nothing but the bare axis. This makes it difficult to visualize the exact arrangement of the polyps in life, but it seems to be much less regular than in most of the Primnoids. On some of the terminals, which seem to be well preserved, I have counted five whorls in 10 mm. of length with two or three polyps in each whorl, as in the type ; but some of the secondary branches the polyps are not arranged in whorls and often in thick clusters or irregularly scattered about.

The largest polyps are almost cylindrical in shape and about 1·2 mm. in height by 0·35 mm. in diameter.

They are protected by scales arranged in a manner similar to that of the type as shown by Kükenthal (1919, p. 419). He gives the size of these scales as 0·3–0·36 mm. in breadth. This is in agreement with the scales of some of the larger polyps of the Maldive specimens.

The marginal scales are provided with a long spine, which is very brittle and frequently broken off at the tip. In some scales, however, it is 0·45 mm. in length.

The axis of the terminal twigs is 0·15 mm., and of the branches supporting them 0·6 mm. in diameter. All these branches of the axis have a glistening brown colour, but when placed in an acid give a strong reaction, showing that they are heavily laden with calcareous matter.

On the surface of the axis of some of the larger branches there is a thin chalky deposit, corresponding with the thick layer of this substance on the base of attachment.

All parts of the axis show shallow longitudinal grooves at the surface.

The type of this species was found by the " Valdivia " Expedition in 1644 metres off the East African coast, and this single specimen was well described by Kükenthal.

Thomson and Henderson (1906, p. 42) gave to some fragments of this genus from 703 metres in the Laccadive Seas the name *Thouarella moseleyi* var. *spicata*. This variety was said to differ from the type of *T. moseleyi*, which was dredged by the " Challenger " Expedition in 600 fathoms, by several characters, and it is by some of these characters that it resembles more closely the Murray specimens of *T. flabellata*.

There can be little doubt that the specimens obtained by the " Investigator ", " Valdivia " and Murray Expeditions from the Indian Ocean all belong to the same species, and that that species is the only one of the genus from those waters of which we have any record.

Genus *Caligorgia* Gray, 1857.*

Although some of the species of this genus have a superficial resemblance to some of the species of *Primnoella*, it seems to be quite well-defined by the prominent spined opercular scales and by the elaborate ornamentation of the other scales of the verrucæ.

It is, however, a most difficult genus for the identification of its species. No less than thirty species have been described from nearly all the seas of the world, and one of them—*C. flabellum*—seems to have a cosmopolitan distribution. Six of these species have been described from the Indian Ocean.

No information has yet been obtained about the growth-stages of any one species, nor any careful study made of the extent of variation in an individual colony or series of colonies from the same locality. The result is that many of the characters given for the distinction of species are obviously artificial and misleading.

Caligorgia indica Thomson and Henderson.

C. indica Thomson and Henderson, 1906, p. 43.

Station 157, 229 metres, Maldives.

One perfect specimen and a few fragments were obtained at this station.

The former is 180 mm. in height and 150 mm. in breadth, and in form it is a perfect flabellum. The general appearance of the branches is feathery, but as some of the larger ones are dichotomous and the smaller branches which support the terminals are not straight but zig-zag, the branching is, I suppose, technically dichotomous.

The polyps are not more than 1 mm. in length. They are arranged laterally in pairs, but in some places an additional polyp makes with the others a whorl of three.

There are 7–8 of these pairs in 10 mm. of the length of the branch.

Only a part of the base of attachment is preserved, in the form of a bulbous expansion (5 mm. in diameter) at the end of the main stem, which is covered by a thick calcareous coat, as in *Thouarella flabellata*.

I have not studied the characters of the verrucæ very thoroughly because they seem to agree very fully with the description of the type given by Versluys in Thomson and Henderson's paper (1906, p. 43).

There are, however, 7 scales on the abaxial vertical rows, and the number of scales on the outer lateral rows is reduced to 3 or 4. The opercular scales are prolonged into a spine-like process and have a total length of about 0·4 mm., and the plate-like base a diameter of about 0·3 mm.

The type of this species was found in the Andaman Archipelago at a depth of 73–502 metres, but Thomson and Simpson (1909, p. 180) subsequently described a specimen of the same species from a depth of 54–90 metres in the Laccadive archipelago.

The type specimen was submitted to Versluys for examination, who compared it with the closely-allied species *C. similis* but considered it to be distinct (see Thomson and Henderson, 1906, p. 43).

I am inclined to think, however, that both these species will prove to be only local varieties of the widespread species *C. flabellum*.

* For the story of the spelling of this generic name see Wright and Studer, 1889, p. 75.

Caligorgia flabellum Ehrenberg.

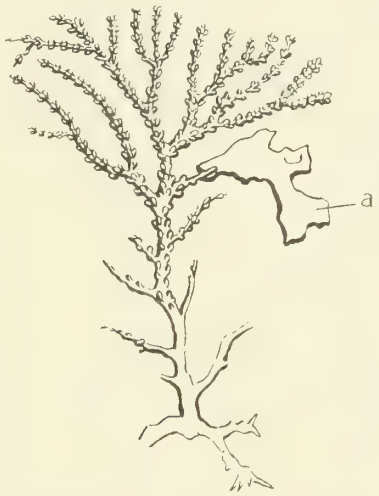
Prymnoa flabellum Ehrenberg, 1834, p. 358.

Station 24, 73–220 metres, off Cape Guardafui.

This very interesting specimen is only 50 mm. in height by about 40 mm. in width (Text-fig. 9).

The base of attachment is fixed to the horny branch of a specimen of the hydroid Ceratella, and from it rises a bare stem bearing seven short dead or moribund branches. At its distal end it divides and gives rise by dichotomous branching to a perfect little flabellum.

One branch has been partly smothered by a colony of Polyzoa (Cellepora ?).



Text-fig. 9.—*Caligorgia flabellum*. *a*, A branch overgrown by Cellepora. Nat. size.

The polyps are arranged in whorls of 4 or 5, and there are 6–8 whorls on 1 cm. of a branch. They are about 1·3 mm. in length as they are adaxially bent.

The scales on the abaxial side bear a pattern of ridges and spines very similar to those shown by Versluys in his text-figure (1906*a*, fig. 77, p. 70).

There may be some doubt as to the identity of this specimen on account of its dichotomous branching. It is, however, a very small and probably young form, and there is no evidence, at present, as to the early stages of growth of any species of the genus.

C. flabellum may attain to a great size. A specimen examined by Versluys was 1 metre in height, and other specimens that have been referred to the species were said to be of large dimensions. In all these specimens and many fragments the branching was feather-like (" federartig "), but this description is based principally on the character of terminal branches of large specimens, and it is possible that in the early stages the branching is dichotomous.

The characters of the scales, the numbers of polyps in a whorl and the size of the polyps are probably more reliable characters for the determination of species, and in these respects the small specimen from Station 24 is most closely related to the widespread species *C. flabellum*.

Caligorgia dubia sp. ? Thomson and Henderson (Pl. I, fig. 2.)

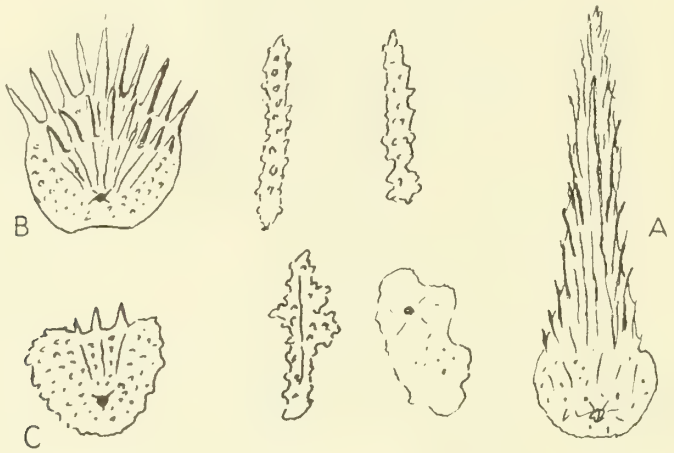
C. dubia Thomson and Henderson, 1906, p. 45.

Station 143, 797 metres, Maldives.

This specimen is referred, with some hesitation, to the species proposed by Thomson and Henderson for a fragment obtained by the " Investigator " in 732 metres in the southern part of the Bay of Bengal.

It is also only a fragment, as the main stem and base of attachment are missing. It is 95 mm. in height and gives off from the stem very slender branches, alternately right and left in one plane. There are twelve terminal branches and the longest of these is 40 mm. in length.

The polyps are about 1 mm. in total length and the cœnenchym between them is very



TEXT-FIG. 10.—*Caligorgia dubia.* A, A scale at the margin of a verruca; B and C, other scales on the verrucæ; D, E, F, G, spicules of the cœnenchym. × 200 diams.

thin and transparent. Considerable damage was done to this delicate structure in the processes of capture and preservation, many polyps and parts of the cœnenchym being lost; but judging from the best preserved branches the polyps are arranged in regular whorls of two or three about 1 mm. apart and in some places odd polyps are found.

The abaxial side of the verrucæ is protected by 7 or 8 rows of overlapping scales in addition to the long-spined scales at the distal end which together form the operculum.

Each transverse row consists of 4 scales which, in the contracted condition, overlap laterally.

The number of the opercular scales seems to vary in different polyps, but the maximum number with prominent spines I have been able to count is five.

They vary also considerably in size and in proportions. In one such spicule, which may be considered to be typical, the total length is 0·4 mm., the spine being about 0·3 mm. in length and the base 0·1 mm. in diameter. The most characteristic feature of these scales is the spine, which seems to be composed of a process of the base of the scale bearing numerous diverging ridges produced laterally into small tooth-like spinelets at the edges (Text-fig 10, A).

The scales of the row immediately below the operculum (Text-fig. 10, B) are 0·2–0·3

mm. in diameter, are ornamented with 7 or 8 pronounced ridges diverging from a common centre and terminating distally in one or two rows of prominent spines.

In the succeeding rows the scales are reduced in size and the number of the ridges and spines fewer and less prominent (Text-fig. 10, c). On all these scales the surface is dotted with minute tubercles.

The surface of the cœnenchym between the verrucæ is protected by flat tuberculate scales closely fitted together to form a complete armour. When separated they are seen to have an infinite variety of shapes (Text-fig. 10, d–g).

The axis is round in section and has a rough and rather granular surface. At the base of a terminal branch it is about 0·3 mm. in diameter, but tapers off at the end to a very fine thread.

The colour of the colony is very pale yellow.

The description of the type of this species was not very full and was not illustrated by any figures or diagrams. It was 79 mm. in height. But our specimen agrees with the type in the number of polyps in a whorl, the size of their scales, the presence of spines on their margins, the long spine on the opercular scales and in some other minor characters.

Species that are founded on fragments only are notoriously unsatisfactory ; but on comparing this specimen from Station 143 with the other two species from the Indian Ocean I have examined, it seems to be undoubtedly distinct and that, most probably, it belongs to the species described by Thomson and Henderson.

The only other species which shows opercular spicules comparable with those of the Maldive species is *C. formosa*, described by Kükenthal (1919, p. 368) from the Nicobar Islands in 362–750 metres ; but this species differs from it very markedly in the characters of the other scales of the verrucæ.

Family Acanthogorgiidæ.

Acanthogorgia muricata Verrill (1883, p. 34).

There were specimens of *Acanthogorgia* in the collection from three stations. From Station 43, off the south coast of Hadramaut, in 95 metres, there were seven colonies ranging in height from 50–120 mm. Five of these were complete, bearing a small disc of attachment.

The ramification is, in all cases, in one plane, and most of the branches stand out at right angles to the main stem.

The long slender polyps are close-set all round the branches, with an average height of 5 mm. from the base of the verrucæ to its spiny margin. In all cases the anthocodiæ are completely retracted into the verrucæ. The diameter of the body of the verrucæ is about 0·9 mm., but the margin is a little more expanded.

The long bent spindles of the body wall are arranged more or less *en chevron*.

The number of spines projecting from the margin cannot be accurately counted because some of them are broken off and lost : but there must be at least 12 on most of the verrucæ.

The spicules are all white and have the usual form of the species of the genus.

From Station 157, off the Maldives, in 229 metres, a few fragments only were obtained and are preserved in a bottle containing many specimens of *Bebryce mollis*.

The polyps are much more crowded together in these fragments and, as they are preserved, a good deal smaller, being only 3 mm. in height by about 0·9 mm. in diameter.

There is no difference of any importance between the spicules of these specimens and those from Station 43.

These fragments probably belong to the same variety as those described by Thomson and Henderson (1905, p. 290) from Trincomalee under the name *A. muricata* var. *indica*.

From Station 24, off Cape Guardafui, in 73–220 metres, there is a small but complete specimen of the same species.

The height of the specimen is only 70 mm. and the main stem bears nine branches which are almost exactly bilaterally arranged. The longest branch is 40 mm. in length and bears no branchlets. Of the other eight, only one bears lateral branchlets.

The polyps are smaller than those of the specimens from the other localities, being only 2 mm. in height and about 0·8 mm. in diameter. The spicules and their arrangement on the walls of the polyps cannot be distinguished from those of more typical examples.

Sir Arthur Thomson and his partners are responsible for referring an Indian Ocean species of *Acanthogorgia* to Verrill's species *A. muricata*, described from specimens obtained off Barbados. If this identification is correct the species has a remarkably wide distribution extending from the Indian Ocean, through the Mediterranean Sea to the Atlantic Ocean and the West Indies.

Thomson and Simpson (1909, p. 192), after an examination of a large number of examples of this species collected from various localities extending from the Andaman Islands to the Red Sea, came to the conclusion that the species is very variable and that "many of the characters on which new species (of this genus) have been formed are of doubtful significance." On this ground, therefore, it seems probable that the reference of these specimens to Verrill's species is sound.

In a recent publication, however, Deichmann (1936, p. 151) expresses the opinion that *A. muricata* is identical with *Blepharogorgia schrammi* of Duchassaing and Michelotti. Gray's genus *Acanthogorgia* (1857) has priority over *Blepharogorgia* (1864), and therefore the name of the species would become *Acanthogorgia schrammi*.

In my opinion this very inconvenient change of name should not be adopted until the authenticated type specimen of *Blepharogorgia schrammi* has been found and re-investigated.

The name given to the genotype by Gray (1857, p. 128) was *Acanthogorgia hirsuta*.* Unfortunately, its locality was unknown; but it is possible that it came from the West Indies and is identical with *A. schrammi*.

Family Chrysogorgiidæ Verrill, 1883, p. 21.

Dasygorgiidæ Wright and Studer, 1889, p. 1.
Chrysogorgiidæ Versluys, 1902, p. 2.

This family of deep-sea Gorgonacea includes six well-defined genera and one (*Metallogorgia*) which may be considered to be of doubtful significance (see p. 308).

It is represented in the collection by two species of *Chrysogorgia* and two species of *Radiceps*.

* The only figure of *A. hirsuta* was published in the 'Proceedings of the Zoological Society', 1851, pl. iii, but, owing to a mistake of the artist, under a different name. It is remarkable that the genus *Acanthogorgia* is not mentioned in Gray's 'Catalogue of the Lithophytes in the British Museum', 1870.

There has been in past years some doubt as to the proper name of the Family. Wright and Studer, having expressed some uncertainty as to the systematic position of the type species *Chrysogorgia desbonni* (D. and M.), changed the family name to Dasygorgiidæ ; but Versluys, having proved that the species referred to—*Dasygorgia*—cannot be separated from *Chrysogorgia*, restored the older family name. Finally, Deichmann (1936, p. 228), having examined a large number of specimens of *Chrysogorgia desbonni* in the Harvard Museum, confirmed Versluys' views, and the family name Chrysogorgiidæ is now generally accepted.

Genus *Chrysogorgia* Duchassaing and Michelotti.

Dasygorgia Verrill, 1883, p. 21.

This genus is represented in the collection by specimens dredged at four stations off the Maldive Archipelago at depths of 256–1280 metres and from two stations off the coast of Arabia at depths of 1046–1450 metres, which are referred to the species *Chrysogorgia flexilis* ; and from one station off the Maldive Archipelago in 225 metres, which are referred to *Chrysogorgia cupressa*.

Most of the seventy specimens of *C. cupressa* are complete with a stalk of attachment, *C. flexilis* is represented by only two specimens that are approximately complete, and by numerous fragments of various sizes.

There are exceptional difficulties in the identification of the species of this genus and in separating some of them from Versluys' genus *Metallogorgia*.

No less than fifty named species of *Chrysogorgia* are mentioned in Kükenthal's monograph (1924), and many of these have been described from single specimens or fragments, and therefore important specific characters are, in many cases, unknown.

No consideration seems to have been paid by previous authors to the possibilities of variation in the species or in the individual, and the characters of the species seems to have been based on the examination of only one polyp or of a small branch.

Some of these characters are of very questionable value ; for example, such a statement as that the spicules are pointed spindles and of certain length in millimetres in one species and that in another they are rod-shaped and of a smaller or greater length.

In all the preparations I have made there is an immense variety in the shape and size of the spicules. In some the spindle-shaped spicules may predominate over the rods, or vice versa, but I have never found any preparation without some spindles and some rods. The difficulty of describing accurately any one spicule preparation may be appreciated by a glance at the figures given by Wright and Studer (1889, pl. v) of the spicules of several species of *Chrysogorgia* (=*Dasygorgia*). These figures seem to have been drawn at random by an artist and they show no definite characters by which one species could be distinguished from another. In many groups of Alcyonaria each species has its own characteristic spicules. No such spicules are found in *Chrysogorgia*.

The height of the polyps is often given as a diagnostic character of a species. What does this mean ? It is probable that no polyp with the anthocodia fully expanded has yet been seen and, consequently, this measurement can only refer to that part of the body-wall which is strengthened by an armature of spicules, the verruca. But this varies enormously in size in every specimen.

The largest polyps in any specimen, preserved in spirit, are usually those that are

pregnant with gonads. They are more or less cylindrical in shape with a swelling at the base or higher up, wherever the gonads are situated. The spicules are arranged longitudinally and frequently form triangular points at the distal margin. Such points are well shown in Kükenthal's figure of *Chrysogorgia flexilis* (1919, text-fig. 230, p. 519). On the same branch may be found polyps that are not pregnant, with the body-wall contracted to form a low mound, one quarter or less than the height of the pregnant polyp, and in such a condition the spicules are arranged transversely or more or less irregularly, no points being visible. Between these two forms many intermediates can be found.

Another great difficulty is to distinguish between the genera *Metallogorgia* and *Chrysogorgia*. The name *Metallogorgia* was given to the genus by Versluys (1902, p. 87) on account of the brilliant metallic colours of the axis of its stem and branches. But this character is by no means confined to the two species of this genus. In all the specimens of *Chrysogorgia* collected by the Murray Expedition the surface of the axis has a metallic iridescence similar to, but not always so brilliant as, that of *Metallogorgia*. This character is not, therefore, a reliable one for the genus.

In all the descriptions of the species attributed to the genus *Metallogorgia* (see Versluys, 1902, p. 88 ; Kükenthal, 1924, p. 388) the colony is supported by a long stem, up to 730 mm. in length, which bears only a few small or very rudimentary barren branches. At the top, this stem divides either dichotomously or in two almost equal branches, which subdivide and give rise to the great racemose mass of the colony.

This kind of stem was called by Versluys " monopodial " to distinguish it from the stem of *Chrysogorgia*, which he called " sympodial " ; and, according to this author, affords the only character which distinguishes the two genera.

It is the character given by Kükenthal (1924, p. 383) in his key index as a guide to the zoologist.

When the stem divides at its upper end into two equal or sub-equal branches and gives rise to much ramification, the method of branching becomes sympodial (Versluys, 1902, p. 87), as it is in *Chrysogorgia*.

Consequently, specimens without a stem and fragments of colonies above the stem have lost the only character which distinguishes *Metallogorgia* from *Chrysogorgia*, and the systematist cannot possibly tell, with any degree of certainty, to which genus such specimens should be referred.

In this collection, made by the Murray Expedition from seven different stations, only two stems with the discs of attachment are preserved (leaving out of consideration for the moment the specimens of *Chrysogorgia cupressa*). One of these has the appearance of a stem of a *Metallogorgia*, the other of a *Chrysogorgia* (Text-fig. 11). A comparison of these two stems suggests that there is, in reality, no essential difference between a " monopodial " and a " sympodial " stem.

These two specimens were found at Stations 159, 1280 metres, and 158, 914 metres, respectively, both close together, west of the Maldive Archipelago. In the following paragraphs they will be referred to simply as 159 and 158, respectively.

In 159 a part of the stalk bearing the base of attachment has been broken off in preservation. This is 150 mm. in length, but another part 180 mm. in length remains attached to the bushy expansion. Assuming, then, that nothing has been lost, the total length of the stalk was 330 mm. in length. This very long slender stalk varies very little from 1 mm. in diameter throughout its length. The stalk of 158 has a total length of 120

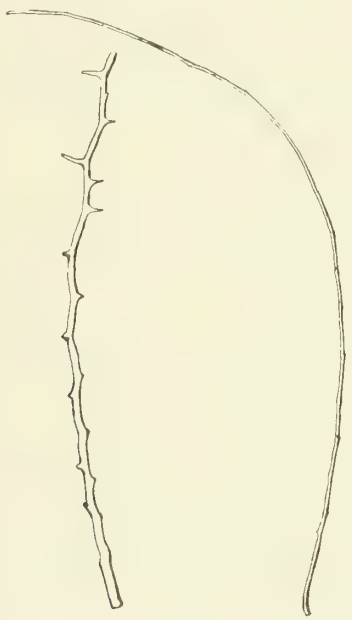
mm. and its diameter is almost uniformly 2 mm. At first sight there can be no doubt that the stalk of 159 would be referred to *Metallogorgia* and that of 158 to *Chrysogorgia*.

But the striking differences they show seem to lose their importance when they are more closely examined.

On both there is a series of small spine-like processes, which undoubtedly are remains of branches which were present in the earlier growth-stages of the colony.

In 158 these processes are arranged spirally at distances of 3–8 mm. apart. In 159 they are very much smaller and situated at distances of 8–10 mm. apart. In both there is a slight bend or kink in the stem opposite the point of origin of the processes, but this bend is much more pronounced in 158 than in 159.

I have not been able to determine whether the axis cylinder of these branches is or is



Text-fig. 11.—*Chrysogorgia flexilis*. Stems of specimen from Station 158 (left) and from Station 159 (right). × ⅔ length.

not continuous with that of the main stem, but on comparing the figures of the stems of *M. melanotrichos* given by Versluys with those of *M. macrospina* by Kükenthal and the two stems shown in Text-fig. 11 from the Murray collection, it is very difficult to believe that there is really any essential difference between the so-called " monopodial " and " sympodial " type of stem.

For these reasons, therefore, I have referred both the specimens from Stations 158 and 159 to the genus *Chrysogorgia*.

It is fortunate that in both of them a part of the base of attachment is present. In 158 it is quite irregular in shape, with a greatest expanse in one direction of 10 mm. In 159 it is much smaller, with a greatest expanse of only 5 mm. In both the surface is marked by numerous shallow grooves radiating from the place where the horny stem plunges into a thick calcareous mass. On treating a fragment of the base with H.Cl. there is a small residue consisting of a spongy mass of a substance which may be horny. The calcareous substance is quite amorphous. There are no spicules in it.

If these were the only two specimens in the collection they would undoubtedly be regarded as representatives of two distinct species for the following reasons :

The branching of 158 is much denser than it is in 159, the axis of the branches are thicker, the internodes shorter, and the polyps on the terminal branchlets more numerous.

It is impossible to reduce these statements to exact figures, but it may be said that the proximal ends of the branches of 158 are 1·5–2 mm., and of 159 are not more than 1 mm. in diameter, the internodes of the former are rarely more than 10 mm. in length, of the latter many are 30 mm. or more in length.

The least retracted polyps of 158 are smaller than those of 159 and the armature of spicules is mainly composed of small rods instead of long spindles, but there is such a big range in the size of the polyps even on a single branch of either specimen due to age or to a condition of pregnancy that any figure that may be given of the actual size must be taken with some reserve.

The largest pregnant polyp of 158 in my preparations is 1·3 mm. and of 159 2·5 mm. in height. These figures may be taken to represent roughly the difference in size between the polyps of the two specimens.

The body-wall of these two polyps is protected by an armature of spicules which in 158 are mainly rods with rounded extremities and a maximum length of about 0·4 mm., and in 159 long spindles with a maximum length of about 0·9 mm. (Text-fig. 12). In 158 the rods are arranged somewhat irregularly and mainly parallel to the long axis of the polyp ; in 159 the spindles are much more regularly arranged in the same direction, and at the distal end form eight triangular groups similar to the points of the calyx of other Alcyonaria (see Kükenthal's figure of *C. flexilis*, 1919, p. 519). When these characters, however, of the two polyps are compared with other polyps of the same specimens, so many different arrangements of the spicules are found that it is difficult to define accurately what are the essential differences between them.

None of the polyps are fully expanded. All that we have to examine are different stages of contraction, and as the contraction was probably rapid and unnatural the spicules have become more or less distorted in most of them. If we compare the figures of the polyps of *Chrysogorgia flexilis* given by Wright and Studer (pl. iv, fig. 2), by Versluys (p. 46, fig. 63) and by Kükenthal (p. 519, fig. 230) it is seen that there is no agreement between these authors as to the pattern of the spicules of the polyps in this species.

The larger size of the spicules of 159 and the difference in shape as compared with those of 158 might suggest that there is a good specific distinction between the two specimens, but in spicule preparations of 158 there are not only the rods of various sizes but several long spindles exactly similar to the characteristic spicules of 159 ; and in preparations of 159 a few rods similar to those of 158 are found among the spindles.

The difference between the armature of the polyps of these two specimens, therefore, is not that the spicules are different but that the proportion of rods and spindles is different.

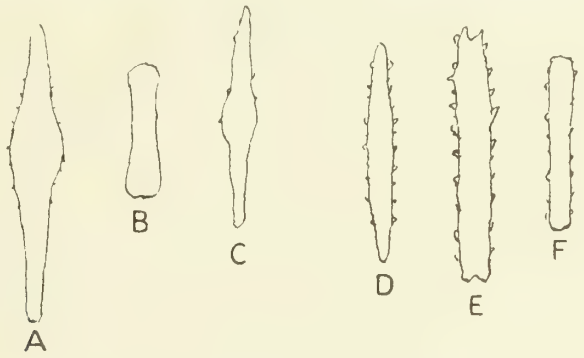
There are, fortunately, in the collection several fragments of specimens from Station 152, 878 metres, and Station 153, 256 metres. They are not so well preserved as the others, the polyps being more tightly contracted. In the density of the branching and in the size and distribution of the polyps they resemble 158 more closely than 159.

The spicules of 152 and 153 are rods very similar in length and shape, but slightly narrower than those of 158. There are, however, in my preparations no long spindles in either specimen.

The fragments from the south coast of Arabia were collected at Stations 42, 1450 metres, and 54, 1046 metres. There can be little doubt that these specimens belong to the same species as those described by Kükenthal (1919, p. 518) as *Chrysogorgia flexilis* var. *africana* from the east coast of Africa in 463–1289 metres of water.

The spicules covering the surface of the polyps of these Arabian specimens are spindles, but of rather a different shape from those of 159 (Text-fig. 12, D). The greatest length of these spicules in 42 is 0·4 mm. and in 54 0·5 mm. The surface of many of these spicules is very rough and in some the minute denticulations are of the size of small tubercles. There is, in this respect, such an immense variation that it is not a good character for the determination of the species.

The problem of the species.—In the Report by Thomson and Henderson (1906, p. 28) specimens of *Chrysogorgia* from the eastern part of the Indian Ocean were referred to five species. All of these, except those called *C. flexilis*, were fragmentary and from one locality only. *C. flexilis* was found at four stations at depths of 700–1110 metres, and one specimen, at least, retained the stem and a small base of attachment (1906, pl. ii, fig. 3).



Text-fig. 12.—Outline sketches of selected spicules of *Chrysogorgia flexilis*. A, From Station 159 with a few small tubercles; B and C, from Station 158 with a smoother outline, the rods more numerous than the spindles; D, E, F, from Station 42 with many small tubercles. All × *circa* 50 diams.

The specimen shown in this figure is closely related to that from Station 159 in the Maldive Archipelago, although the stem is not so long and the spindles covering the polyps a little shorter. The " Valdivia " Expedition obtained eleven specimens from five stations off the east coast of Africa at depths ranging from 463–1289 metres, which Kükenthal (1919, p. 518) called *C. flexilis* var. *africana*. The spicules of this variety, according to the description, are long rods becoming spindles but even smaller than those of Thomson and Henderson's specimen. Nevertheless, they are very similar to those of the Murray specimen from Station 159.

From the study of these specimens Kükenthal (p. 520) came to the conclusion that depth must have some influence on the structure of the colony. There is, for example, a thicker stem and longer internodes in the forms from deeper waters. This statement is not in accordance with my observations on the Murray specimens, in which the forms from deeper water have longer internodes but more slender stems. It is unfortunate that we have no information as to whether there is any variation in the spicules and other characters in the " Valdivia " specimens.

When an attempt is made to give specific names to the numerous specimens of this genus from the Indian Ocean the fact that no two specimens from different depths are

exactly alike as regards some important characters and that in some, such as the size and armature of polyps, considerable variations may be seen on the same branch of a single colony, the question arises whether we are dealing with one variable or a very large number of distinct species.

All these specimens from the Indian Ocean inhabit deep or very deep water, and it is generally recognized now that in other groups of Cœlenterata deep-sea species are very widespread geographically and liable to considerable variation in form and some other characters.

The probability, therefore, is that we are dealing with one species which varies according to the nature of the sea-bottom, the strength and direction of the currents, and other features of the environment in deep water.

A muddy bottom may lead to more rapid growth, producing a longer and more slender stem. Scarcity of food brought by the sea-currents may induce the production of longer internodes and larger and more scattered polyps.

In the forms from less than 1000 metres in depth the stems are usually shorter, the branching more compact and the polyps smaller and more numerous than in those from deeper water, and this may be correlated with lesser mud and stronger sea-currents.

In this connection it may be noted that the specimen of *C. flexilis* var. *africana* shown in Kükenthal's pl. xxxi, fig. 12, came from a depth of only 463 metres and has a much shorter stem than the Murray specimen from Station 159 from 1290 metres, which in many other respects it closely resembles.

If the view be accepted that all these specimens from the Indian Ocean belong to one species the question arises as to which of the species already described they should be assigned. In my opinion they should be referred to the *Chrysogorgia flexilis* of Wright and Studer (1889, p. 10).

The type of this species came from 219 metres off the island of Chiloe on the coast of Chili. Specimens from several stations in the Malay Archipelago were referred to the same species by Versluys (1902, p. 10) and by Thomson and Henderson, and by Kükenthal, as mentioned above, from the Indian Ocean. Like other deep-sea species, therefore, it has a wide distribution in deep water, and there is no reason for separating the Indian Ocean forms from the type, because they are so widely separated geographically.

Chrysogorgia flexilis Wright and Studer.

Dasygorgia flexilis Wright and Studer, 1889, p. 10.

The principal characters of this species are: Colony supported by a long stem rising from a calcareous base of attachment, with barren rudimentary branchlets. Branches long and racemose, arranged in a spiral manner, with long internodes and widely-separated polyps, very slender and flexible. Spicules, spindles and rods with or without small tubercles, and very variable in size and arrangement. Axis smooth with brilliant metallic lustre, covered in life with a very thin cœnenchym bearing a few irregular plates and scales. World-wide distribution in deep water.

From the investigation of the examples of this species collected by the Murray Expedition there appear to be some slight differences between those collected in the Maldive Archipelago and those from the east coast of Africa and South Arabia, and they may, therefore, be separated, provisionally, as local varieties.

C. flexilis var. *africana* Kükenthal.

Most of the spicules spindle-shaped, and some of them provided with minute or small tubercles.

Stations 42, 1450 metres, and 54, 1046 metres.

C. flexilis var. *maldivensis*. New variety.

Most of the spicules rod-shaped and very rarely provided with tubercles.

Stations 152, 153 and 158, 229–914 metres.

The specimen from Station 159 seems to be intermediate between these two varieties.

Chrysogorgia cupressa Wright and Studer (1889, p. 11).

About seventy examples of this species were dredged at Station 157, 229 metres, off the Maldive Archipelago.

Of these only five were complete with a base of attachment. Most of the others seem to have been broken off close to the base of the stalk.

The largest specimen in the collection is 130 mm. in height, but of the five complete specimens the largest is only 60 mm. and the smallest 45 mm. in height.

In a note it is stated that 11 " Munida " crabs, 3 Ophiurids and 1 barnacle were associated with these specimens. To these may be added 2 specimens of *Paracyathus conceptus* which formed the support of two of the colonies of *Chrysogorgia cupressa*.

These solitary corals seem to be very common in deep water off the Maldives (Gardiner and Waugh, 1938, p. 184).

The general form of the colonies is that which has been described as like a " bottle-brush " or, by Wright and Studer, as " a delicately-branched conifer ".

The main stem arising from a small disc of attachment is of variable length, is jointed, and from its upper end the branches spring in a left-handed spiral. There are four branches to each twist of the spiral.

The sub-division of the branches is in a manner similar to that shown in Wright and Studer's diagram, fig. 4 on p. 21 of their monograph.

The spicules are confined to the outer surface of the body of the polyps and to the aboral sides of the tentacles. They are short rods with rounded ends, and are covered with numerous minute denticulations. They vary enormously in size, but the average of a number of the larger ones is about 0·2 mm. in length by 0·028 mm. in breadth. The fig. 45 on p. 21 in Versluys' monograph (1902) is a good representation of such an average spicule.

There are no spicules preserved in the very thin cœnenchym between the polyps.

I have not studied the characters of the verrucæ very thoroughly because they seem to agree very fully with the description of the type given by Versluys (1902, p. 43).

The specimens collected by the Murray Expedition agree very closely with the descriptions given by Wright and Studer and by Versluys (1902, p. 40) of the type of *Chrysogorgia cupressa* from 140 fathoms (252 meters) off the Kei Islands in the Malay Archipelago. The distance between the Kei Islands and the Maldives is undoubtedly very great, but the numerous examples of the widespread distribution of the deep-sea

Alcyonarians affords no reason for supposing that the Murray specimens must belong to a different species from the type.

Versluys has described three new species from the Malay Archipelago which, together with *C. cupressa*, belong to his group Spiculosæ and sub-group A1.

Unfortunately, there was only one specimen of each of these three new species, and consequently Versluys was unable to study the variation in any of them. In the large collection of specimens from the Maldives there is clearly considerable variation in some respects, a thorough study of which might lead to very interesting results. Until this has been done the " Siboga " new species must be accepted with some reserve. One of the species described by Versluys (*C. tetrasticha*) was dredged in the Kei Archipelago in 204 metres of water, that is in the same locality and in approximately the same depth as that in which the type of *C. cupressa* was found. If *C. tetrasticha* is really a distinct species it will be a very exceptional case of two deep-sea species of Alcyonaria, closely related to each other, living in the same locality and in approximately the same depth of water.

Genus *Radiceps* Stearns (1883, p. 97).

Lepidogorgia Verrill, 1884, p. 220.
Strophogorgia Wright and Studer, 1889, p. 3.
Radiceps Kinoshita, 1913, p. 5.

There can be no doubt that Kinoshita was right in giving to the name Radiceps for this genus the right of priority.

Radiceps aureus ? Kükenthal (1919, p. 544).

There is one specimen belonging to this genus from Station 145, 494 metres, Maldives, which I found in a tube containing a number of specimens of *Pennatula inflata*. In general appearance it resembles closely the picture of *Strophogorgia challengeri* given by Wright and Studer (1889, pl. i, fig. 1). It is 260 mm. in length and its diameter in the middle is 1·8 mm. The polyps are arranged in a single row at regular distances of 2 mm. apart. The total length of the two polyps I examined was about 1·5 mm. The needle-like spicules on the abaxial side of the polyps reached a maximum of 0·9 mm. in length.

These polyps have the appearance of having been dead when captured, and it was impossible to determine the characters of their tentacles. The base of attachment is calcareous and gives irregular branches over the support similar to those shown in Wright and Studer's figure on their pl. i, fig. 1, of *Strophogorgia challengeri*.

The type of *R. aureus* was discovered by the " Valdivia " Expedition in 1644 metres of water off the coast of tropical East Africa. Specimens referred to *Radiceps challengeri* were found in deep water in the Atlantic Ocean.

In his key-index to the species of the genus, Kükenthal (1924, p. 410) gives as a distinction between the two species that the abaxial tentacle is rudimentary in *R. challengeri*, but not rudimentary in *R. aureus*. This is a character which could not be determined in the Murray specimen.

The two species are closely related, as also is *R. verrilli*, of which a specimen has been described from the Andaman Islands in 685 metres by Thomson and Henderson (1906, p. 26).

I have put a mark of interrogation after the specific name of the Murray specimen because on the evidence it might belong to any one of these three species.

Radiceps squamiferus Kükenthal (1919, p. 545).

Station 106, 212 metres, Pemba Channel.

One example of this species, 100 mm. in length with a diameter of 0·4 mm., was found in the same region in which the type specimens were discovered by the "Valdivia" Expedition. It agrees so closely with the excellent description of the type given by Kükenthal that, beyond making one preparation of two polyps, I have not thought it worth while to make any further examination.

Kükenthal was able to study ten specimens from off Dar-es-Salaam and four from the Zanzibar Channel in 463 metres.

Order PENNATULACEA.

Kophobelemnon pauciflorum Hickson (1916, p. 72).

A single rather damaged example of this species was obtained from Station 171, south-west off Cape Guardafui in 3872 metres of water. It is about 120 mm. in total length and bears only three large autozooids.

There is an abundance of spicules in the tentacles and in the outer layers of the rachis. All these spicules are ridged needles with a maximum length of about 1 mm.

The genus *Kophobelemnon* does not appear to be common in the Indian Ocean, and it therefore seemed to be of interest to record the existence of this specimen, which was inadvertently omitted from my monograph of the Pennatulacea of the Murray Expedition.

K. burgeri was described by Thomson and Henderson (1906, p. 88) from 170 metres in 13° N. by 80° E., and a new species by Thomson and Simpson (1909, p. 277) called *K. intermedium* in 95 metres in the Gulf of Martaban.

The latter was considered to be intermediate in some respects between the genera *Kophobelemnon* and *Sclerobelemnon* on account of the absence of spicules in the tentacles. The specimen described above differs from this species in having numerous spicules in the tentacles, and from *K. burgeri* in having very few autozooids.

It agrees very closely with the species *K. pauciflorum*, which seems to be fairly common in the Malay Archipelago (Hickson, 1916, p. 72).

Anthoptilum inermis Thomson and Henderson (1906, p. 91).

There is one, damaged and badly preserved, specimen in the collection from Station 70, 196 metres, off the coast of Hadramaut, which is probably identical with the species described by Thomson and Henderson under the generic name *Thesioides*.

It is a very slender form with a total length of about 170 mm. and the greatest diameter of the rachis is 0·6 mm. Some of the autozooids are isolated or in pairs, but there are one or two places in which there seem to be leaves of three or four polyps. The specimen, however, is so damaged that it is impossible to determine exactly what the normal condition was like.

No spicules were found in either the autozooids or in the rachis.

The type specimens of *Thesioides* were found in the eastern part of the Indian Ocean at depths of 818–845 metres.

The genus has been transferred to *Anthoptilum* (see Hickson, 1916, p. 138).

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DESCRIPTION OF PLATE I.

FIG. 1.—*Nicella reticulata.* A part of a large colony stripped of its cœnenchym to show the arrangement of the anastomoses. Two-thirds natural size

FIG. 2.—*Caligorgia dubia?* The only fragment in the collection. It bears an epizoic Ophiuroid. A little larger than natural size.

FIG. 3.—*Stenogorgia sewelli* n. sp. A terminal branch of Specimen A.

FIG. 4.—*St. sewelli* n. sp. A terminal branch of Specimen B.

FIG. 5.—*Menacella sladeni.* Half natural size.

FIG. 1.

FIG. 5.

FIG. 2.

FIG. 3.

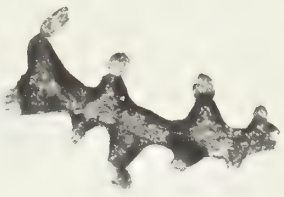

FIG. 4.

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THE

JOHN MURRAY EXPEDITION

1933–34

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OSTRACODA

BY

H. GRAHAM CANNON, Sc.D., F.R.S.

The University, Manchester

WITH THREE TEXT-FIGURES

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WITH THREE TEXT-FIGURES.

THE following is a list of the Ostracods collected by the John Murray Expedition to the Indian Ocean, 1933–34. Apart from two representatives of the genus *Gigantocypris*, including one valuable new species, there were no other specimens of any particular interest.

Family CYPRIDINIDÆ.

Sub-family CYPRIDININÆ.

Genus *Cypridina* Milne-Edwards.

Cypridina (*Macrocypridina*) *castanea* G. Brady.

OCCURRENCE :

St. 172. N. 100. 850–0 m. 1500 m.w.o. One (juv.).
St. 186. N. 100. 250–0 m. 510 m.w.o. One (juv.).
St. 186. N. 100. 575–0 m. 880 m.w.o. One (juv.).

REMARKS.—All three specimens showed the characteristic lack of pigmentation and more globular shape than the adult.

Genus *Gigantocypris* G. W. Müller.

Gigantocypris mülleri Skogsberg.

OCCURRENCE :

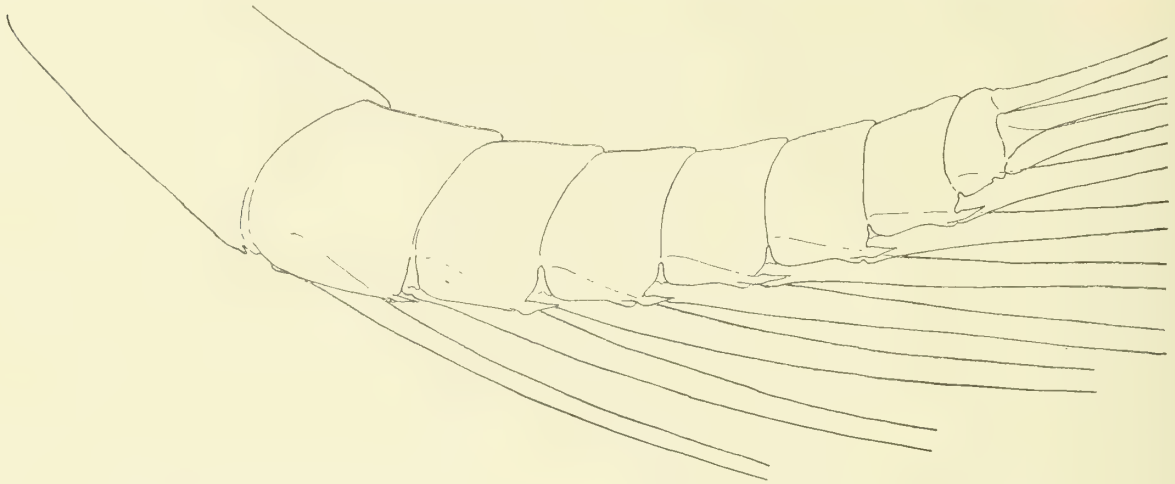
St. 61. N. 200. 2000–0 m. 2265 m.w.o. One (full sized, somewhat damaged).
St. 131. N. 200. 2500–0 m. Vertical haul. One (juv.).

REMARKS.—I have pointed out elsewhere (1940, p. 190) that the differences between Skogsberg's type *G. mülleri* and Müller's *G. agassizii* are very unsatisfactory. The only character of any useful value is that in the original type described by Müller, the conical spines present at the bases of certain natatory setæ of the antennal exopodite are absent while they are present in Skogsberg's form (Text-fig. 1). According to this distinction the single adult John Murray Expedition specimen must be named *G. mülleri*. I have

compared it with the very complete account given by Skogsberg (1920) and can find no appreciable difference. Unfortunately the tips of both second trunk limbs were absent, so that it was not possible to count the number of cleaning bristles, but, as I have pointed out, this is probably of little significance.

Müller (1895) merely states that in his form the spines are missing from the bases of the natatory setæ (p. 158). Skogsberg (p. 216) goes further and says that the exopodite has no basal spines on the 3rd to the 9th joint. In the John Murray specimen and in all the "Discovery" specimens that I have examined the spines are present on the 3rd to the 8th segment. There is even a trace of a spine on the 2nd joint, but never any on the 9th.

Until the type specimens of *G. agassizii* can be re-examined it is of course impossible to settle whether or not Müller's statement as to the lack of these spines was based on inaccurate observation. I think, however, that this is extremely likely as these spines are sometimes very difficult to make out. The angle that each spine subtends at its apex



TEXT-FIG. 1.—*Gigantocypris mülleri*. Exopodite of antenna to show spines at the bases of the natatory setæ. × 60.

agrees with the angle at which the natatory setæ project from the axis of the exopodite. Because of this, if the exopodite is mounted one way up the spines are practically invisible in any ordinary mounting medium.

Skogsberg refers to his type as the Atlantic form, and to the original species as the Pacific form. The John Murray Expedition specimen upsets this distinction, as without doubt it agrees with Skogsberg's form, and yet was found in the Indian Ocean. Müller (1906, p. 135), however, did describe *G. agassizii* as occurring in the Pacific. Skogsberg suggests (1920, p. 216) that this diagnosis was incorrect, for he points out that the picture of the whole animal published by Müller was undoubtedly different from his own Pacific form. I feel certain that the specimen figured by Müller was badly distorted, not so much from the side view, in which the profile is different from any good specimen of *Gigantocypris* that I have seen, but from the ventral view, in which the free edges of the valves are gaping apart. This never occurs in an undistorted specimen.

The only other species of *Gigantocypris* hitherto described is *G. pellucida* Müller. This was first described from a single specimen caught at the same time as the original

G. agassizii in the Pacific. However, Fowler (1909), Lüders (1909) and Skogsberg (1920) all take the view that this form is actually the immature stage of *G. agassizii*. Another specimen collected by Scott (1911) is taken by Skogsberg to be the same as his *G. mülleri*, although from the meagre description given by Scott I find it difficult to see how Skogsberg places it in one species rather than the other.

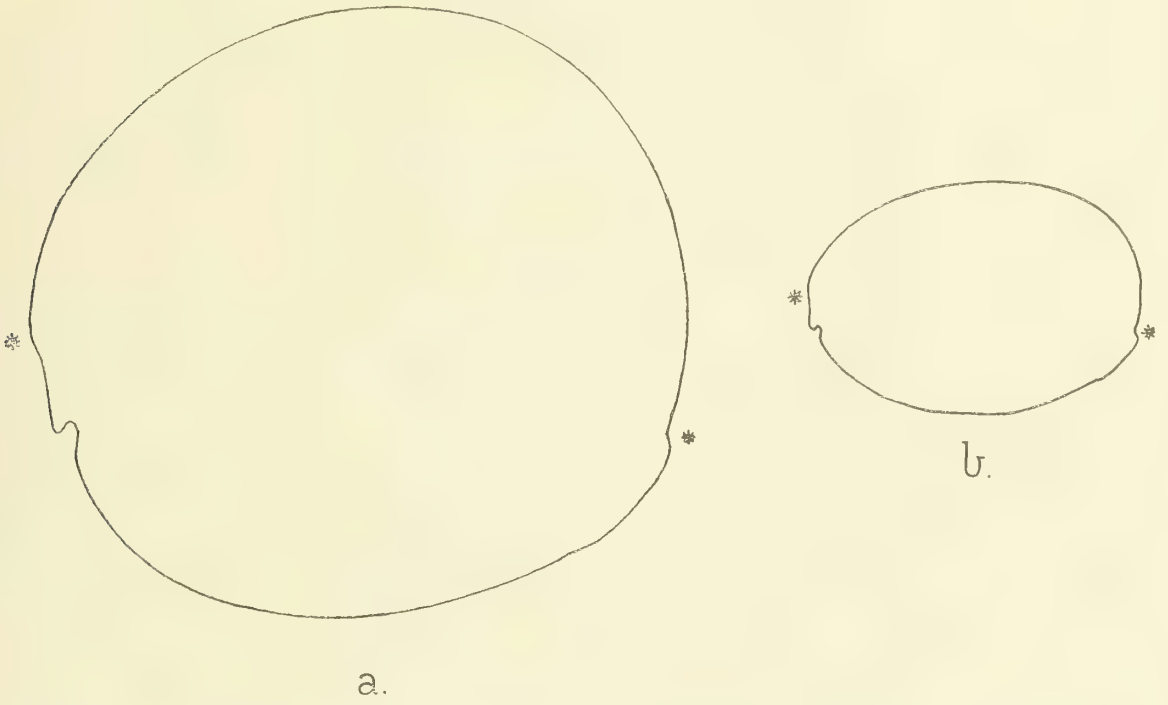
There is thus, I consider, considerable evidence that the three forms previously described as separate species really represent one widespread species.

Gigantocypris dracontovalis n. sp.

Occurrence :

St. 98. N. 200. 2800–0 m. 2800 m.w.o. One ♀.

Remarks.—The single specimen collected at Station 98 with 2800 metres of wire out was a large ovoid ostracod with an extremely delicate shell. It clearly belonged to the



Text-fig. 2.—(*a*) Outline of *G. mülleri* based on photograph of "Discovery" specimen. × 4·3. (*b*) Approximate outline of *G. dracontovalis* n. sp. × 4·3. The asterisks indicate the limits of the ventral opening.

genus *Gigantocypris*, because it possessed the enormous and unique nauplius eye. In shape, however, it was much less spherical, resembling in profile the ovoid shape of an ordinary Cypridinid. That it was a distinct form and not merely a young *Gigantocypris mülleri* was shown by the fact that it was a ripe female carrying embryos, and these were only about half the size of the embryo of *G. mülleri*. The most interesting feature was that the opening between the two valves was approximately half of the profile circumference (Text-fig. 2). This could not be measured accurately owing to the delicate nature of the valves, but it was clearly considerably longer than that of *G. mülleri*. Müller (1912, p. 23),

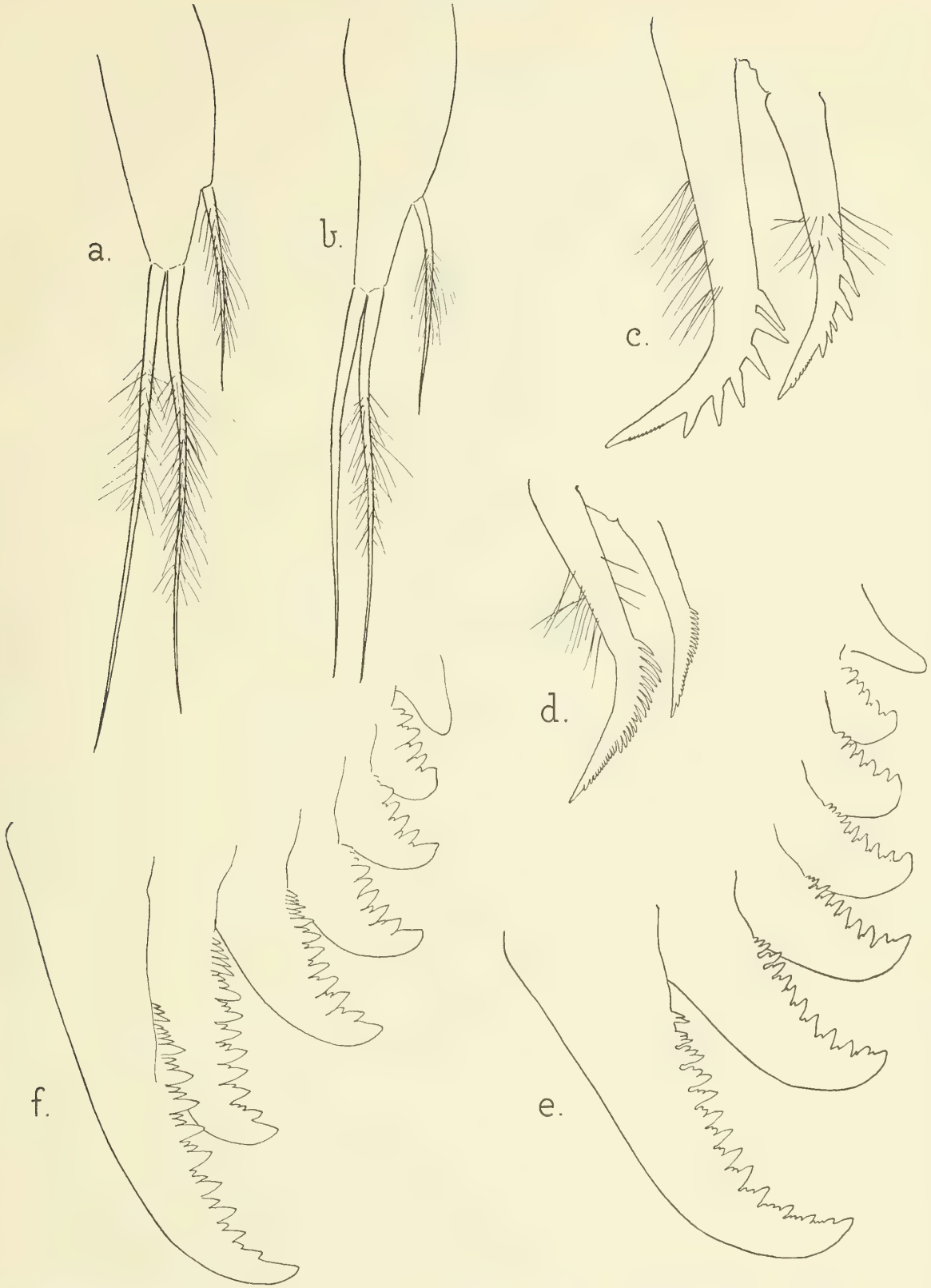
in his diagnosis of the genus *Gigantocypris*, included the statement that the two valves of the shell are fused for approximately two-thirds of the periphery.

I have mounted all the limbs of one side of the specimen, and from a study of these and of the valves there is little doubt that it is the same as two specimens described by Skogsberg as a variety *minor* of his new species *G. mülleri* (1920, p. 219). More particularly it agrees with the specimen which Skogsberg calls species " a."

I give below a table of the most useful distinguishing characters, comparing the Murray Expedition specimen on the one hand with Skogsberg's species " a," and on the other with *G. mülleri.*

	G. mülleri.	*G. mülleri* var. *minor.*	*G. dracontovalis* n. sp.
Shell :			
Dimensions	Length : height : breadth 10 : 9 : 9 (Text-fig. 2)	10 : 8 : 7	10 : 7 : 7 (Text-fig. 2).
Antennal notch	Numerous spines (see Skogsberg, 1920, fig. xxix, 19, p. 214)	Few spines (see Skogsberg, 1920, fig. xxx, p. 221)	Same as var. *minor.*
Spines on rostrum	75–125	45	45
Spines on list	75–125	40–60	48
Mandible :	20–30 cleaning bristles which all show various styles of pectination (see Skogsberg, 1920, fig. xxix, 21, 22, 23)	10–14 cleaning bristles, all of which are smooth	14 cleaning bristles as var. *minor.*
Maxillule :			
Exopodite	Both distal bristles are plumose (Text-fig. 3)	One distal bristle is smooth	Same as var. *minor* (Text-fig. 3).
Maxilla :			
1st endite	14 bristles	9 bristles	Same as var. *minor.*
3rd endite	Penultimate spine bears lateral hairs	Penultimate spine without lateral hairs	,, ,,
	Most posterior spine bears relatively few stout teeth (Text-fig. 3).	Not stated	Most posterior spine bears relatively many slender teeth (Text-fig. 3).
1st exopodite joint	6 bristles in front of main tooth (see Skogsberg, 1920, fig. xxvii, 13)	3 bristles anterior to main tooth	Same as var. *minor.*
	Main tooth characteristic pattern (Text-fig. 3)	Not figured	Main tooth characteristic pattern (Text-fig. 3).
Trunk limb 2 :			
Comb	90–150 teeth	40 teeth	Same as var. *minor.*
Bristles	1–10 bells	3–9 bells	,, ,,
Embryos :			
Number	57–85	27	37
Dimensions	2·1 × 1·9 mm.	Not stated	1·5 × 1·1 mm.

Skogsberg suggests (1920, p. 219) that his specimen was one " whose development has been checked by unfavourable conditions." That this is not so is shown by the size



Text-fig. 3.—(*a*) Exopodite of maxillule, *G. mülleri*. × 49. (*b*) Exopodite of maxillule, *G. dracontovalis* n. sp. × 109. (*c*) Last two claws on 3rd endite of maxilla, *G. mülleri*. × 109. (*d*) Last two claws on 3rd endite of maxilla, *G. dracontovalis* n. sp. × 172. (*e*) Main tooth, *G. mülleri*. × 172. (*f*) Main tooth, *G. dracontovalis* n. sp. × 322.

of the embryos of the new species. They are markedly smaller—approximately half the volume of those of *G. mülleri*. Now a pædogenetic *G. mülleri*—for that is what Skogsberg is suggesting—while it could reproduce at an earlier stage, would still produce normal embryos of the usual size. Unfortunately Skogsberg does not give the dimensions of the embryos of his suggested new variety.

In view of Skogsberg's suggestion I also compared the new form with a young *G. mülleri* of approximately the same size from the " Discovery " collection and also with the young specimen from Station 131 in this collection, and there is no doubt whatever that it cannot be considered as a small form of *G. mülleri*. The antennal notch certainly resembles that of a young *G. mülleri*, but then the shape of the shell is much more ovoid. However, the most marked distinguishing features are (1) that even the young *G. mülleri* has more numerous cleaning bristles which are all pectinate on the mandible, and (2) the second trunk limb has no teeth in the comb at this young stage, whereas the new form has 40, and (3) the bristles bear at the most four bells.

For diagnostic purposes the shape of the shell is of value only if the specimen is undistorted. More often than not, however, in this genus the valves are considerably crushed, so that the real profile of the animal cannot be settled. At the same time also the armature of the antennal notch is useless, as it is the same as that of a young *G. mülleri*. In this case the easiest distinguishing characters are the comb on the second trunk limb and the absence of pectinate bristles on the mandible. Both these points can be settled from the isolated limbs. The further diagnostic features require the dissection of the individual limbs.

From the fact that Skogsberg's specimens were collected in the Atlantic Ocean in an open net fishing at 1500 metres while the type specimen was collected in the Indian Ocean also at a great depth, it appears that this is a widespread species similar in this respect to *G. mülleri*.

In shape the specimen reminded me of the egg of a snake. I accordingly am naming it *G. dracontovalis*.

Family Halocypridæ.

Sub-family Conchœcinæ.

Genus *Halocypris*.

Halocypris globosa (Claus).

Occurrence :

St. 131. N. 100. 500–0 m. Vertical haul. One.
St. 172. N. 100. 200–0 m. 510 m.w.o. One (juv.).

Genus *Conchœcia*.

Conchœcia caudata G. W. Müller.

Occurrence :

St. 131. N. 100. 1500–0 m. Vertical haul. Two ♀.
St. 172. N. 100. 400–0 m. 820 m.w.o. One ♂.

Conchœcia atlantica (Lubbock).

St. 96. N. 200. 400–645 m. 919 m.w.o. Nine.
St. 131. N. 100. 500–0 m. Vertical haul. One.
St. 131. N. 100. 1500–0 m. Vertical haul. Two.
St. 172. N. 100. 200–0 m. 510 m.w.o. One + three (juv.).
St. 172. N. 100. 400–0 m. 820 m.w.o. Twenty.
St. 172. N. 100. 850–0 m. 1500 m.w.o. Seventeen.
St. 186. N. 100. 250–0 m. 510 m.w.o. Three.
St. 186. N. 100. 575–0 m. 880 m.w.o. Two.
St. 186. N. 100. 600–0 m. 1150 m.w.o. Fourteen.

Conchœcia plinthina G. W. Müller.

St. 61. N. 100. 1500–0 m. 1699 m.w.o. One ♀ + three (juv.).

Conchœcia imbricata (G. Brady).

St. 96. N. 200. 400–645 m. 919 m.w.o. One ♀.

Conchœcia alata G. W. Müller.

St. 76. N. 100. 600 m. 800 m.w.o. One.
St. 76. N. 100. 1500 m. 1800 m.w.o. Three.
St. 172. N. 100. 200–0 m. 510 m.w.o. Six.
St. 172. N. 100. 400–0 m. 820 m.w.o. Three.
St. 172. N. 100. 850–0 m. 1500 m.w.o. Ten.
St. 186. N. 100. 250–0 m. 510 m.w.o. One.
St. 186. N. 100. 575–0 m. 880 m.w.o. Two.
St. 186. N. 100. 600–0 m. 1150 m.w.o. Thirty-two.

Conchœcia daphnoides (Claus) var. *minor* G. W. Müller.

St. 96. N. 200. 400–645 m. 919 m.w.o. One ♀.

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